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## NATURAL HISTORY OF THE SILICA MINERALS\*

AUSTIN F. ROGERS, *Stanford University.*

For any mineral or group of minerals there are two general classes of facts to be ascertained: (1) the geometrical, physical, and chemical properties; (2) the mode of occurrence, association, and origin, or briefly what may be called the natural history of the mineral.

To the geologist, of course, the natural history of a mineral is its most attractive feature, but until the mineral is accurately defined and determined, the significance of its occurrence and origin may be lost sight of.

It is my purpose to discuss the various silica minerals. The silica minerals are with a single exception accurately defined; they have been produced in the laboratory; they constitute the most complete example of polymorphism known. They are, moreover, of considerable geological interest, and altogether we have a fairly good idea of the rôle that the silica minerals play in Nature.

Let us first consider briefly the silica minerals and their properties as a background for the discussion of their natural history.

### LOW QUARTZ

Though by no means the most common, quartz is probably the best known of all minerals. The ancient Greeks called it *crystallus*, in the belief that it was permanently congealed water, and thus was derived our word crystal.

Quartz has been investigated from almost every standpoint, and its physical constants have been very accurately determined. The symmetry of low quartz is trigonal trapezohedral ( $A_3 \cdot 3A_2$ ). Twinned crystals of quartz are not uncommon. The twinning may be reflection-twinning (Japan law), rotation-twinning

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octahedrons, in spherulites alone, and in spherulites intergrown with orthoclase. In mode of occurrence it is much like tridymite.

In 1918 it was described by the writer<sup>5</sup> from two localities in California, and since that time it has been found in more than a dozen localities in the western part of the United States. It is a widely distributed mineral, but usually occurs in small quantities. In this country it is known from more localities than is tridymite.

A typical occurrence of cristobalite in minute secondary spherulites in the lithophysae of a rhyolitic obsidian from Little Lake, Inyo County, California, has been described by the writer.<sup>6</sup>

Cristobalite and tridymite are of more than purely scientific interest. The artificial minerals are the principal constituents of silica bricks,<sup>7</sup> which are made by burning ground-up quartzites containing from 97 to 98 per cent of silica. Fig. 6, Plate II represents a thin section of silica brick in ordinary light. The curved fracture of cristobalite is characteristic. The specimen of silica brick was kindly furnished me by my colleague, Professor W. J. Crook.

#### LECHATÉLIÉRITE

The latest of the silica minerals to be described is lechatélierite, named by Lacroix<sup>8</sup> in 1915 in honor of Henry Le Chatelier, the famous French chemist, whose work<sup>9</sup> on silica and silicates is well known. Lechatélierite is naturally occurring silica glass. It has not been generally recognized as a distinct mineral.

In its properties lechatélierite is much like opal, but in origin it is absolutely different. As Miers<sup>10</sup> has well said: "The essential characters of a mineral, moreover, are quite independent of its source or previous history. . . ." This statement is important for crystalline minerals, but is probably not valid for amorphous substances such as opal and lechatélierite. At any rate, it is convenient to treat these two as distinct minerals. About a century ago Breithaupt distinguished two classes of

<sup>5</sup> *Am. Jour. Sci.*, [4], vol. 45, pp. 222-226 (1918).

<sup>6</sup> *Jour. Geol.*, vol. 30, pp. 211-216 (1922). (See Fig. 1 on p. 213).

<sup>7</sup> McDowell, Bull. 119, *Am. Inst. Min. Eng.*, pp. 1999-2055 (1916).

<sup>8</sup> *Bull. Soc. Fran. de Min.*, vol. 38, pp. 182-186 (1915).

<sup>9</sup> *La Silice et les Silicates*, Paris (1914).

<sup>10</sup> *Mineralogy*, p. v., London, (1905).



amorphous substances, the hyaline or glasses and the porodine or those of colloidal origin. It is unfortunate that the term hyalite has been used as a variety of opal.

Lechateli rite is unique in that it is the only naturally occurring glass that is definite enough to be considered a mineral.

Lechateli rite is the chief constituent of fulgurites which are formed by the fusion of quartzose sand by lightning. It also occurs in some volcanic inclusions. There is a unique occurrence at Meteor Crater, in Arizona, which I shall describe later. Plate I, Fig. 4 is a photograph of a thin section of the lechateli rite from Meteor Crater.

Silica glass, which is often incorrectly called "quartz glass", is now made on a commercial scale in a very pure transparent form. Silica glass possesses some unusual physical properties such as transparency to ultraviolet light and a remarkably small coefficient of thermal expansion. A rod of the glass 1 meter in length will expand only about 0.6 mm. for a rise of temperature of 1000 C. Some remarkably clear silica glass has recently been produced by the General Electric Company at Lynn, Massachusetts.<sup>11</sup>

#### THE SILICA MINERALS IN GENERAL

The various silica minerals and some of their properties are shown in the tabulation given on p. 78. All the known forms of silica, and they are legion in number,<sup>12</sup> are believed to be synonyms or varieties of the ones mentioned. Asmanite, found in meteorites, is a synonym of tridymite. Lussatite, considered by some to be distinct form, is probably a mixture of opal and fibrous chalcedony.

It seems probable that all the forms of silica capable of existence at atmospheric pressures are now known. But it is not safe to say that all the possible distinct forms of silica are known, for polymorphism is a general phenomenon of nature and there is no theoretical limit to the number of polymorphous modifications of any chemical substance.

The stability relations of most of the silica minerals is shown in a diagram which appeared in a paper by Fenner<sup>13</sup> of the Geophysical Laboratory, published in 1913.

<sup>11</sup> Berry, *Smithsonian Report for 1924*, pp. 213-218.

<sup>12</sup> Hart, this journal, vol. 12, pp. 383-395 (1927).

<sup>13</sup> *Amer. Jour. Sci.*, [4], vol. 36, pp. 331-384 (1913).

TABULATION OF THE SILICA MINERALS

Mineral	Crystal Form	Sp. Gr.	$n_{\alpha}$ $n_{\gamma}$	Stability Range
OPAL (Pliny, 77)	Amorphous (Porodine)	2.1 -2.2	1.44 -1.46	....
CHALCEDONY (Agricola, 1546)	Aggregate structure	2.57-2.63	1.533, 1.543	....
LOW QUARTZ (Wallerius, 1747)	Trigonal trapezohedral ( $A_3$ , $3A_2$ )	2.65	1.544, 1.553 at 20°C. 1.535, 1.543 at 570°C.	<575°C.
HIGH QUARTZ (LeChatelier, 1889)	Hexagonal trapezohedral ( $A_6$ , $6A_2$ )	....	1.533, 1.540 at 580°C.	575°-870°
LOW TRIDYMITE (vom Rath, 1887)	Orthorhombic (?) (Pseudo-hexagonal)	2.28	1.469, 1.473	None
LOWER HIGH TRIDYMITE (Mallard, 1890)	?	....	.... ....	None
UPPER HIGH TRIDYMITE (Fenner, 1913)	Hexagonal	....	.... ....	163°-1470°
LOW CRISTOBALITE (vom Rath, 1887)	Tetragonal (?) (Pseudo-isometric)	2.23	1.484, 1.487	None
HIGH CRISTOBALITE (Mallard, 1890)	Isometric	2.20 (290°C.)	....	200°-275°-1625°
LECHATELIÉRITE (Lacroix, 1915)	Amorphous (Hyaline)	2.21	1.458	> 1625°

The artificial production of the various forms of silica under specified conditions in the laboratory has been a great help in the proper understanding of their natural history.

Let us next consider the typical modes of occurrence of the various silica minerals with a view of determining, as far as possible, the conditions under which they were formed in nature.

#### OCCURRENCE OF OPAL

Opal is a late secondary mineral found in seams and cavities of various rocks, especially of volcanic igneous rocks. It is found in sedimentary beds which are in part at least formed from diatoms, radiolaria, and sponge spicules. Opal is unique in that it is the only silica mineral of direct organic origin. It must be formed over a considerable range of temperature, for it is found as geyserite in hot springs, and as a coating formed in broken rock surfaces made since the opening of quarries. For example, I have found it on broken Pennsylvanian limestones at Kansas City, Mo.

It seems plausible to regard opal as a mineral which has formed rapidly. Our information concerning the formation of minerals of colloidal origin is rather meager.

#### OCCURRENCE OF CHALCEDONY

Chalcedony is a typical metacolloid, a convenient term introduced by Wherry<sup>14</sup> to denote microcrystalline minerals of colloidal origin. Its temperature range is probably considerably less than that of low quartz, for it seems to be limited to deposits formed near the surface. It is probably formed more rapidly than low quartz and this may account for its characteristic properties. The exact conditions of its formation, however, are unknown. More study is needed.

#### OCCURRENCE OF LOW QUARTZ

Low quartz is a typical hydrothermal mineral which is probably always formed below 575°C. Its temperature range is considerable. Its occurrence as secondary enlargements of sand grains in sandstones as well as numerous occurrences in sedimentary rocks proves that it may be formed at temperatures at little above the ordinary. Vein quartz usually has a prismatic habit.

<sup>14</sup> *Jour. Wash. Acad. Sci.*, vol. 4, p. 112 (1914).



## OCCURRENCE OF HIGH QUARTZ

High quartz is the original mineral of persilicic igneous rocks present because there is an excess of silica left over after the affinities of silica for the various oxides are satisfied. At atmospheric pressure under laboratory conditions it is formed above 575°C. but in nature it has probably been formed at lower temperatures because of the influence of mineralizers. 575°C. as a point on the geological thermometer<sup>15</sup> cannot be accepted too literally.

High quartz usually shows a bipyramidal habit due to the minor development of the prism faces. (See Plate I, Fig. 1).

## OCCURRENCE OF TRIDYMITITE

Tridymite is the stable form of silica between 870°C. and 1470°C. under laboratory conditions. In occurrence it is practically confined to volcanic igneous rocks. As a rule it is formed after cristobalite.

According to Fenner<sup>16</sup> "tridymite is sometimes found as an essential constituent of acid effusives, associated in such manner with other minerals as to imply its separation from the melt as a primary constituent." I doubt very much whether tridymite is ever formed as a magmatic mineral.

The "acid effusives" referred to by Fenner are the tridymite latites from the Creede district, Colorado, recently described by Emmons and Larsen.<sup>17</sup> Concerning these rocks it is said that the "tridymite forms in large part during the later stages of the crystallization of the groundmass."

For my part, I doubt whether tridymite is ever even a late magmatic mineral. The tridymite latite is a dark red-brown banded rock with irregular streaks and lenses of a paler tint which are coarsely crystalline and contain abundant euhedral crystals of tridymite. A similar occurrence of tridymite from Catalina Island, off the coast of southern California, has been studied by the writer. (See Plate II, Fig. 7). The tridymite-bearing streaks I would interpret as having been formed by pneumatolytic metamorphism. The term pneumatolysis was originally used by Bunsen for volcanic processes, but has since

<sup>15</sup> Wright and Larsen, *loc. cit.*

<sup>16</sup> *Loc. cit.*, p. 344.

<sup>17</sup> Bull. 718, U. S. Geol. Surv., p. 48 (1923).

been employed largely in connection with alterations brought about by emanations from intrusive rocks.

In my opinion tridymite is not a magmatic mineral, but a metamorphic one. The occurrence of euhedral crystals in cavities may be explained by local migration of the silica.

To substantiate my conclusion that tridymite is a product of metamorphism I wish to present briefly the results of my study of a tridymite-feldspar rock which occurs near the Salton Sea in Imperial County, California.

This rock makes up the whole of a small hill which before the recession of Salton Sea was known as Cormorant Island. A prospector, on sinking a shaft on this island or hill, was overcome by gas, and sent the rock encountered to Stanford University for identification. It proved to contain tridymite as an essential constituent. The rock superficially resembles a calcareous tufa. Field work proved that the white to light gray tridymite-feldspar rock was formed from a typical rhyolitic obsidian. The obsidian is found as bands and lenses in the tridymite-bearing rock. These bands and lenses are clearly residual. The origin of this unusual rock type has been confirmed by the microscopic examination of a considerable number of thin sections.

Gradations may be recognized from rhyolitic obsidian through spherulitic obsidians (Plate III, Fig. 9) and dense devitrified obsidians (cristobalite-barbierite rocks) (Plate III, Fig. 11) to porous somewhat banded tridymite-barbierite (the feldspar is a monoclinic one with soda dominant over potassa, so that Schaller's term "barbierite" is used) rocks (Plate III, Fig. 12). Chemical analyses confirm the field and microscopic work. The final stage is a distinctive rock type which must be regarded as metamorphic if we adopt the definition of metamorphism suggested by Daly<sup>18</sup> and used by Holmes<sup>19</sup> and others. The metamorphic agent was doubtless hot gases. The presence of hot springs around the hill and mud volcanoes in the immediate vicinity lends support to this theory of origin.

#### OCCURRENCE OF CRISTOBALITE

Under laboratory conditions cristobalite is stable between 1470° and 1625°C. In nature it is practically always found in

<sup>18</sup> *Bull. Geol. Soc. Am.*, vol. 28, p. 375 (1917).

<sup>19</sup> *The Nomenclature of Petrology*, p. 155, London (1920).



volcanic igneous rocks and is a frequent associate of tridymite. It is far more common in volcanic glasses such as rhyolitic obsidians, than is tridymite. It occurs frequently in cavities and has been formed either at a very late magmatic period or at a very early period of alteration, due to hot gases, in all probability.

My study of cristobalite-bearing rocks convinces me that it is a characteristic mineral of spherulites (pseudospherulites of Rosenbusch) as an interstitial mineral between the rods or fibers of feldspar. Plate II, Fig. 8 is a photograph of a portion of a cristobalite-feldspar spherulite from Casa del Diablo, Mono County, California, collected by Mr. Robert Loofbourow. This interstitial mineral has usually been identified as tridymite or quartz or sometimes as opal. In the younger rhyolites and obsidians this interstitial material is cristobalite. If the interstitial mineral of persilicic spherulitic rocks is cristobalite, it means that it is not such a rare mineral as has been supposed. In the older devetrified rhyolites, quartz is found between the fibers of feldspar of the spherulites. This does not necessarily mean that quartz here is an original mineral. In fact it seems probable that in these cases quartz is an alteration product of cristobalite. There is as yet no direct proof of this, but it seems a reasonable explanation.

#### OCCURRENCE OF LECHATÉRIÉRITE

Above 1625°C., silica glass under laboratory conditions is the stable form of silica. It is certain that such a temperature has not often been reached on or near the earth's surface and it is no wonder that lechatérite is such a rare mineral.

I now wish to describe a unique occurrence of silica glass. The locality is Meteor Crater, or Coon Butte, a crater-like depression about three-fourths of a mile in diameter and nearly 600 feet in depth, in Coconino County, Arizona, near the main line of the Santa Fé railway.

Around the rim of this immense depression there are beds of a white saccharoidal sandstone, a red calcareous sandstone, and an arenaceous magnesian limestone which are more or less disturbed from their original horizontal position.

The white or pale gray saccharoidal sandstone (Coconino sandstone) has been altered to three different kinds of material as follows: (1) rock flour, (2) a rather dense, somewhat banded



quartz rock of a unique type, the quartz grains of which show in thin sections prominent rhombohedral cleavage, and (3) a vesicular glass of nearly pure silica which is the lechatélierite. Microscopic examination proves conclusively that the silica glass is the result of fusion of the saccharoidal sandstone. This was first proved years ago by G. P. Merrill,<sup>20</sup> and of this fact there is not the slightest doubt.

A thin section section of the loosely-consolidated sandstone is shown in Plate IV, Fig. 13. Plate IV, Fig. 14 shows the highly vesicular silica glass. The three oval areas represent what were originally sand grains now converted entirely to lechatélierite. Plate IV, Fig. 15 represents a thin section of a banded, slightly porous silica glass in which the granular structure of the original sandstone is preserved. In this rock there are few residual specks of quartz, as may be seen when the thin section is examined between crossed nicols. (Plate IV, Fig. 16)

The mineralogist or petrographer is interested in determining the origin of the lechatélierite, and the geologist is primarily concerned with the origin of the crater-like depression which Arrhenius declared is "the most interesting spot on the earth's surface." The fusion of the sandstone and the formation of the depression were without doubt brought about by the same geological agent.

In the immediate region of this depression many hundreds of specimens of meteoric iron (these meteorites are known by the name "Canon Diablo") have been found, and this gave rise to the term Meteor Crater, used for the depression. A possible explanation of the formation of Meteor Crater is that it was due to the impact of an immense meteorite. Barringer,<sup>21</sup> Fairchild, Branner, Tilghman, Elihu Thomson, Magie, and D. L. Webster have expressed themselves as being in favor of the meteoritic theory of origin.

Gilbert, Guild, T. C. Chamberlin, Darton, and recently Thurmond, on the other hand, are in favor of its origin by a steam explosion of some kind and attribute the distribution of the Canon Diablo meteorites to a coincidence.

<sup>20</sup> *Smithsonian Misc. Collections*, vol. 50, pp. 461-498 (1907).

<sup>21</sup> *Meteor Crater in Northern Central Arizona*. Paper read by D. M. Barringer at the 1909 meeting of the National Academy of Science. Privately printed.

Besides the lechatérite and the quartz grains of the sandstone and limestone, the only silica mineral found in any of the rocks of this locality is a minute amount of cristobalite embedded in some of the the lechatérite. Tridymite, chalcedony, opal, and newly formed quartz are conspicuous by their absence.

The nearest volcanic rocks, which are basalts, are about ten miles away. Outside of the vesicular silica glass which occurs in layers at least 6 inches thick, there is nothing at Meteor Crater to suggest vulcanism in any form, and there is nothing except the depression to suggest a steam explosion. One would expect a steam explosion to leave some evidence of its work in some kind of rock alteration, but there is none visible. It is almost inconceivable that a temperature in the neighborhood of 1600°C. (about the melting-point of quartz) could have been reached during any part of a steam explosion even if the steam were superheated.

Taking all the facts into consideration, it seems most reasonable to attribute the formation of Meteor Crater to the impact of a huge meteorite and the fusion of the sandstone to form lechatérite to the heat generated by the impact. If this be true, we have at Meteor Crater, Arizona, a unique spot on the earth's surface, but one that perhaps could be duplicated if we had a complete geological history of the earth.

#### TRANSFORMATIONS OF THE SILICA MINERALS

When the silica minerals are studied in the laboratory, there are found to be two types of inversion:

(1) Inversions of the low and high forms of quartz, tridymite, and cristobalite respectively, which take place rapidly.

(2) Inversions of quartz, tridymite, and cristobalite from one into another. These inversions are sluggish, and so are of geological importance.

The inversion temperatures of the various polymorphous forms of silica have been determined under laboratory conditions by the Geophysical Laboratory.<sup>22</sup>

These laboratory experiments are of course extremely important, but the mineralogist and petrographer are primarily interested in the natural occurrences and transformations.

I next wish to present the results of my study of some of the natural transformations of the silica minerals.

<sup>22</sup> Fenner, *loc. cit.*



## OPAL TO CHALCEDONY

Opal, being amorphous, is unstable. There is evidence that it changes to microcrystalline chalcedony. Many massive specimens of silica consist of mechanical mixtures of opal and chalcedony. The form of silica known as lussatite is in all probability such a mixture.

In the Monterey formation of the Coast Ranges of south central California, bands of massive opal are often in whole or in part converted into chalcedony.<sup>23</sup> The specimen shown in thin section by Plate V, Fig. 17 represents an intermediate stage in the transformation.

## TRIDYMITÉ TO QUARTZ

Paramorphs of low quartz after tridymite were first described by Mallard from the Euganean Hills, Italy, under the name "pseudo-tridymite". These are thin tabular six-sided crystals 3 or 4 mm. in size. They have the form of tridymite, but consist of quartz. Such pseudomorphs have been found at a number of localities. Within the last few years I have collected good examples of quartz paramorphs after tridymite in three different occurrences in Santa Clara County, California. One of these occurrences is an altered vitrophyre which occurs as a "puy" known as Lone Hill, near San Jose. A photograph of a thin section examined in ordinary light and between crossed nicols gives convincing proof of the transformation mentioned. (Plate V, Fig. 18)

Tridymite is unstable under laboratory conditions below 870°C. and so under some circumstances we find it transformed to low quartz by hydrothermal solutions. In confirmation of this it should be noted that the altered vitrophyre contains pyrite.

## TRIDYMITÉ TO CRISTOBALITE

In 1918 I discovered in the cavities of a hornblende andesite at Jamestown, California, crystal aggregates which have the characteristic form of tridymite but consist of cristobalite, as was proved by the refractive index. This is the first record of cristobalite paramorphs after tridymite.<sup>24</sup> Since then a similar occurrence has been described from near Eschwege, Hesse-

<sup>23</sup> Tolman, *Econ. Geol.*, vol. 22, p. 470, plates III and IV, (1927).

<sup>24</sup> *Amer. Jour. Sci.*, [4], vol. 45, pp. 224-225 (1918).

Nassau, Prussia, by Ramdohr,<sup>25</sup> and recently I have found another good example in an andesite from near Tucson, Arizona, kindly furnished me by Professor F. N. Guild.

Both the Jamestown and Tucson occurrences contain acicular crystals of an unusual amphibole and thin tabular crystals of anauxite, a pseudo-hexagonal aluminum silicate first described from Bilin, Bohemia, by Breithaupt in 1838. Ross and Kerr<sup>26</sup> have recently shown that anauxite is an important constituent of some clays. Plate V, Fig. 19, is a photograph of one of the cavities of the Tucson andesite containing the paramorphs, amphibole, and anauxite.

In all the occurrences examined by me in which both tridymite and cristobalite occur together, I have found tridymite to be the later mineral, though Larsen<sup>27</sup> in the Creede, Colorado, rocks, reports cristobalite to be later than tridymite. One would naturally expect to find tridymite paramorphs after cristobalite rather than the reverse, as the temperature would normally decrease on the cooling of the andesite.

In view of the work of the Geophysical Laboratory, I would explain the cristobalite paramorphs after tridymite as due to a hot blast of gas probably brought about by chemical reactions in the gaseous state. In confirmation of this hypothesis, I would mention various alteration products which do not seem to be due to either hydrothermal solutions or meteoric waters, for example, the hematitic dust in the groundmass of the Jamestown andesite. This explanation supports Le Chatelier's<sup>28</sup> view that cristobalite is formed rapidly.

#### CRISTOBALITE TO QUARTZ

The occurrence of quartz-feldspar spherulites in devitrified rhyolites with the same texture as cristobalite-feldspar spherulites in recent rhyolites and obsidians is considered evidence that the transformation of cristobalite to quartz has taken place in nature, but no direct proof can be given at the present time.

#### SUPPOSED TRANSFORMATION OF QUARTZ TO OPAL

The last photograph shown (Plate V, Fig. 20) represents a thin section of opalized wood from the Fernando (Pliocene)

<sup>25</sup> *Centralblatt f. Min. Geol., u. Pal.*, 1920, pp. 33-36.

<sup>26</sup> Personal communication.

<sup>27</sup> Emmons and Larsen, *loc. cit.*

<sup>28</sup> *Bull. Soc. Fran. de Min.*, vol. 40, pp. 44-57 (1917).



near Santa Maria, California, presented to me by my colleague, Professor James Perrin Smith. The area shown is one produced by insect borers of some sort. These seem to be opal paramorphs after quartz, and they were so interpreted. The change of quartz to opal would be a new and interesting type of transformation, and we might invent several hypotheses to account for this conversion. But even better than multiple hypotheses is the determination of new facts. On discussing this specimen with one of my biology colleagues, Professor Harold Heath, he told me and proved to me that the pellets (excreta) of recent termites are hexagonal in cross-section. The supposed paramorphs are nothing but opalized termite pellets, and these constitute a new type of fossil.

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In conclusion, I would suggest that the various silica minerals constitute one of the most important and interesting of all our mineral groups. While our knowledge in some respects is fairly complete, we have much to learn, especially with regard to the low temperature forms.

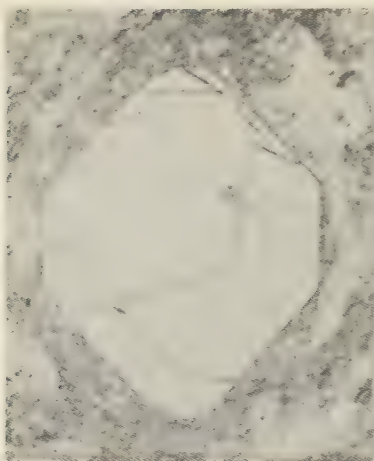


FIG. 1 (X 65).

Phenocryst of high quartz (now low quartz) in rhyolite. Near Stanford University, California.



FIG. 2 (X 18).

Interbanded chalcedony (right center) and low quartz (left center) in Franciscan jasper. Silver Creek, near San Jose, California.

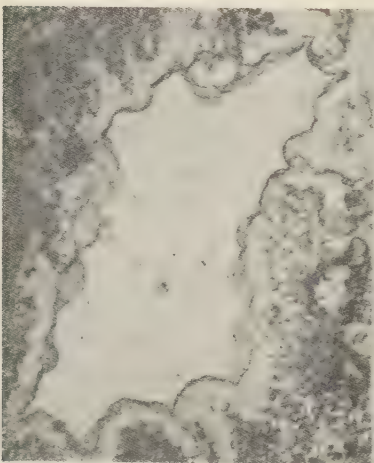


FIG. 3 (X 58).

Colloform opal (high relief) and chalcedony (low relief in center). Near Stanford University, California.

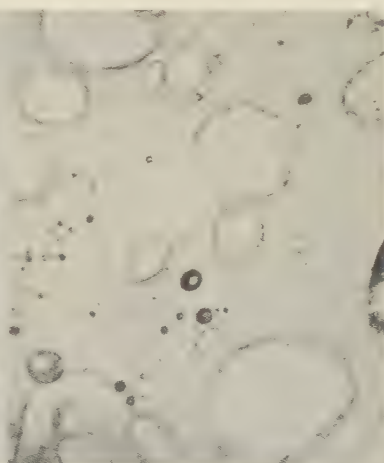


FIG. 4 (X 114).

Lechateliérite (silica glass). The small dark areas are bubbles in the Canada balsam. Meteor Crater (Coon Butte), Coconino County, Arizona.



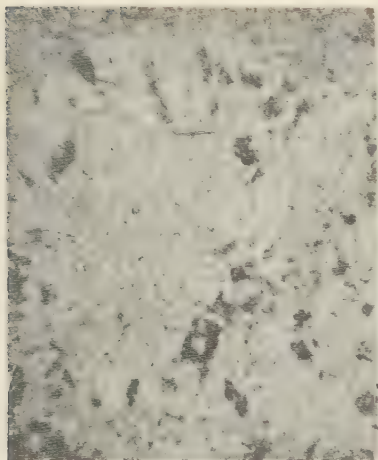


FIG. 5 (X 110).

Cristobalite (area in center with high relief) in cristobalite-feldspar rock (devitrified obsidian). The feldspar is barbierite. Cormorant Island, Salton Sea, Imperial Co., California.



FIG. 6 (X 54).

Artificially produced cristobalite (c) and tridymite (t) in silica brick (Western Star brand).



FIG. 7 (X 25).

Tridymite-bearing streak in porphyritic andesite. Catalina Island, off the coast of southern California.

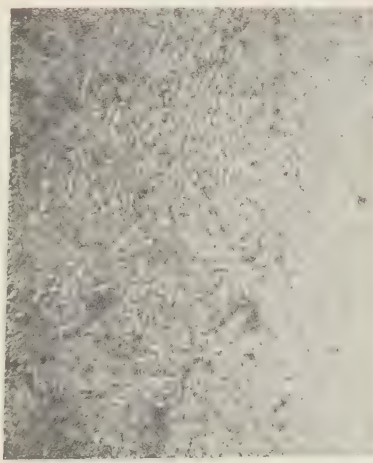


FIG. 8 (X 135).

Portion of a cristobalite-feldspar spherulite from spherulitic rhyolite. (The mineral with high relief is cristobalite). Casa del Diablo, Mono County, California.



FIG. 9 (X 65).

Spherulitic obsidian (rhyolitic). Cormorant Island, Salton Sea, Imperial County, California.

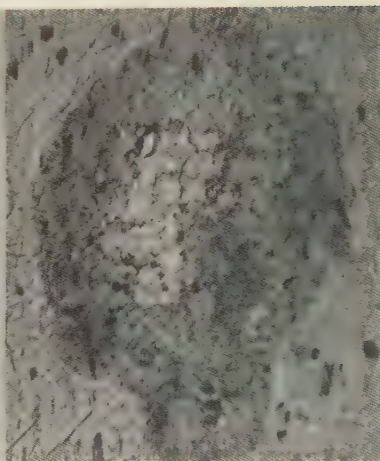


FIG. 10 (X 172).

Spherulite with center of cristobalite (high relief) in spherulitic obsidian. Cormorant Island.

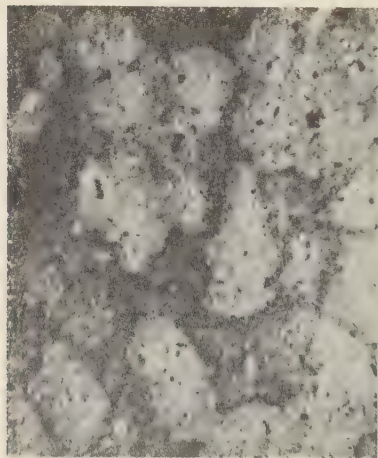


FIG. 11 (X 65).

Cristobalite-feldspar rock showing remnants of spherulitic texture. (The colorless mineral with high relief is cristobalite). Cormorant Island.

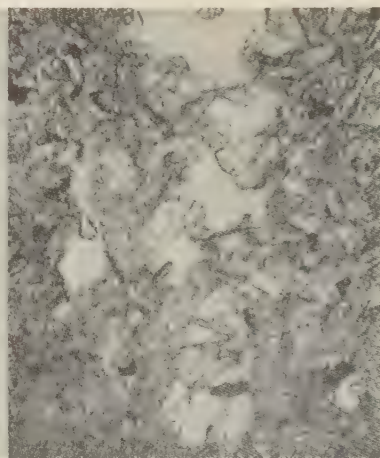


FIG. 12 (X 61).

Tridymite-feldspar rock. (The colorless mineral with high relief is tridymite. The feldspar is barbierite.) Cormorant Island.

PLATE III. THIN SECTIONS OF ROCKS FROM CORMORANT ISLAND, SALTON SEA, IMPERIAL COUNTY, CALIFORNIA



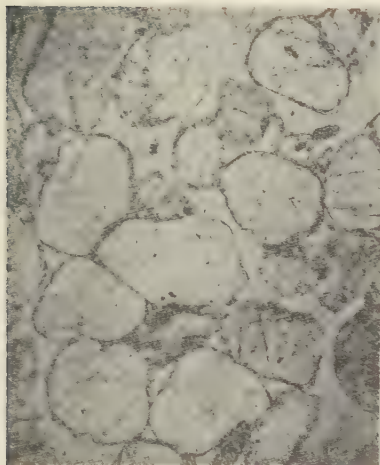


FIG. 13 (X 40).

Saccharoidal sandstone with secondary enlargements of some of the sand grains. Meteor Crater, Arizona.

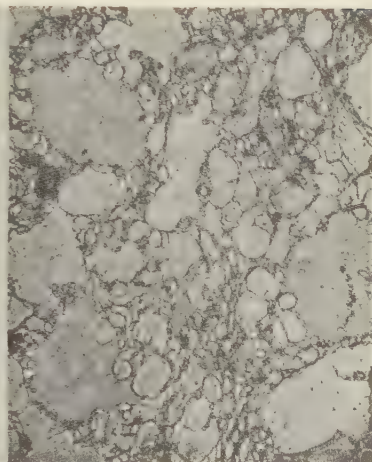


FIG. 14 (X 38).

Lechatéliérite (silica glass) formed by the fusion of the saccharoidal sandstone. Three paramorphs of lechatéliérite after quartz are shown. Meteor Crater, Arizona.

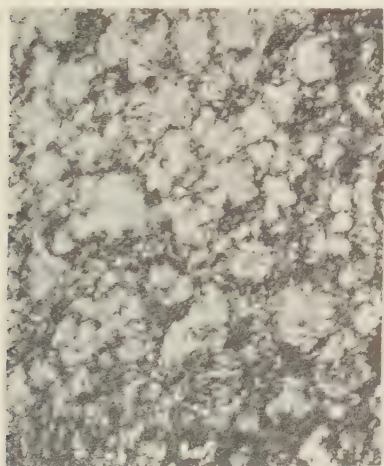


FIG. 15 (X 25).

Lechatéliérite (silica glass) which retains the granular texture of the sandstone from which it was derived. Meteor Crater, Arizona.



FIG. 16 (X 25).

Same as Fig. 15, but taken with crossed nicols. The white spots are relict grains of quartz; the dark field, the lechatéliérite which is somewhat vesicular. Meteor Crater, Arizona.

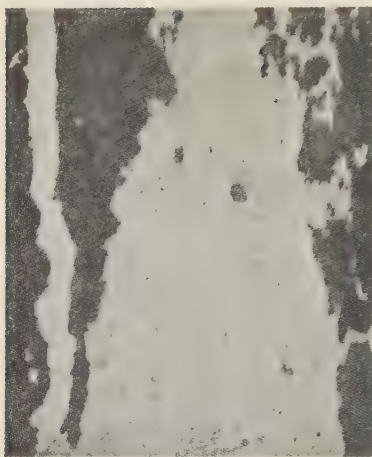


FIG. 17 (X 26).

Opal passing into chalcedony. Monterey formation, near Carmel, California.

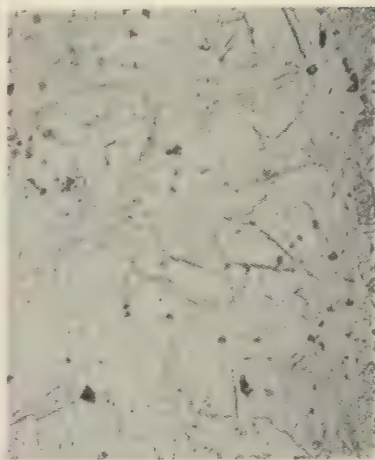


FIG. 18 (X 100).

Tridymite passing into low quartz in cavity filling of altered vitrophyre. Lone Hill near San Jose, California.

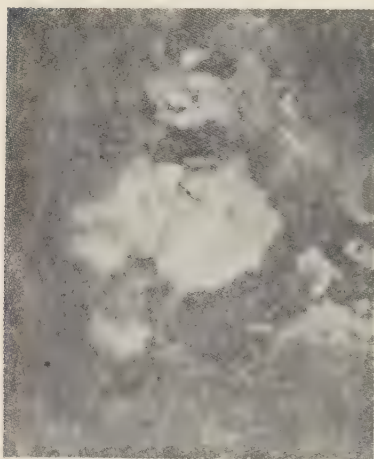


FIG. 19 (X 10).

Cristobalite paramorphs after tridymite in cavity of andesite. The cavity also contains tabular crystals of anauxite and acicular crystals of an amphibole. Near Tucson, Arizona.

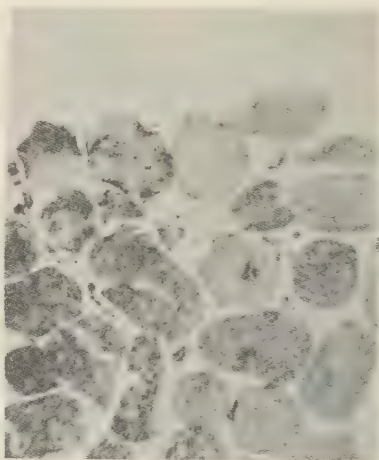


FIG. 20 (X 19).

Opalized termite pellets in opalized wood. The light area at the top shows cell structure of some coniferous wood. Fernando (Pliocene), formation, near Santa Maria, California.

PLATE V. THIN SECTIONS AND HAND SPECIMEN SHOWING TRANSFORMATIONS OF VARIOUS SILICA MINERALS.

## MEMORIAL OF PAUL HEINRICH VON GROTH\*

EDWARD H. KRAUS, *University of Michigan.*

It is with deep regret that we record the death of Professor Paul Heinrich von Groth in Munich, Germany, on December 2, 1927. With the passing of Professor Groth the Mineralogical Society of America has lost one of its most distinguished honorary life fellows, the science of mineralogy one of its greatest leaders,



PAUL HEINRICH VON GROTH  
1843-1927

and the world of science a courageous pioneer, an ardent investigator, an energetic and efficient author and editor, and an inspiring teacher.

Paul Heinrich von Groth was born June 23, 1843, at Magdeburg, Germany. His father was a portrait painter. The training for his life's work Professor Groth obtained at the school of mines in Freiberg, at the college of engineering in Dresden, and at the University of Berlin, at which institutions he spent the years 1862 to 1870. The degree of doctor of philosophy was conferred upon him by the University of Berlin in 1868, his inaugural dissertation being entitled "*Beiträge zur Kenntnis der überchlorsauren und übermangansauren Salze.*" In 1870 he qualified for a teaching position, the subject of the Habilitations-

\* Paper read at the eighth annual meeting of *The Mineralogical Society of America*, Cleveland, Ohio, December 29, 1927.



schrift being "*Über den Zusammenhang der Kristallform und der chemischen Constitution.*"

From 1870 to 1872 Professor Groth was a member of the teaching staffs of the Technische Hochschule in Charlottenburg and of the University of Berlin. When the University of Strassburg was being reorganized, shortly after the close of the Franco-Prussian war, Groth was called to the chair of mineralogy, for he had already acquired a splendid reputation as an investigator of great promise, especially in the field of chemical crystallography to the development of which he subsequently contributed so extensively.

Groth held the professorship at Strassburg from 1872 to 1883. During this period he not only supervised the construction of a new laboratory, which set a very high standard for that time, and completely reorganized the mineral collections, but he also carried on extensive researches and published a long list of papers. Moreover, it was while at Strassburg, that Groth began his notable career as an author and editor, for during that period he wrote two textbooks and a guide to the mineral collections, and founded the *Zeitschrift fuer Kristallographie und Mineralogie*.

Thus, in 1874 the first edition of his *Tabellarische Übersicht der Mineralien* was published, which later appeared in four German editions and in 1904 was translated into French. Two years later, in 1876, his *Physikalische Kristallographie und Einleitung in die Kenntniss der wichtigen Substanzen* appeared. This soon became the standard text in the field of physical crystallography, and later passed through four German editions. In 1910 this important textbook was made more directly available to English-reading students, when portions of it were translated into English by Jackson. The third book to be written by Groth while at Strassburg was the excellent guide to the mineral collections of the University, published in 1878.

As already indicated, the *Zeitschrift fuer Kristallographie und Mineralogie* was founded by Groth. It was first issued in 1877. As sole editor Groth published 52 volumes of the *Zeitschrift* and three more as joint editor with Professor E. Kaiser, making a total of 55 volumes during the years 1877 to 1920. As is well known, since 1921 the *Zeitschrift* has been under the editorship of Professor P. Niggli of the University of Zürich.

Upon the occasion of Groth's eightieth birthday, in 1923, the 58th volume was issued as a *Groth Festschrift*, and contained 32 papers by his friends and former students.

The number of the *Zeitschrift* which was issued in November 1927, only a few weeks before Professor Groth's death, contains as its leading article a splendid account by Professor Groth of the founding and development of the *Zeitschrift* during the first fifty years of its existence, 1877-1927. In this paper Professor Groth refers to the long list of eminent scientists from all over the world who have contributed to the *Zeitschrift* and it is of great interest to note that many of them had been his students either at Strassburg or Munich.

In 1883 Professor Groth was called to the University of Munich as the successor to Professor Wolfgang Franz von Kobell. His tremendous energy was at once transferred to that institution, and he soon reorganized the instruction in mineralogy and installed in new quarters the extensive royal Bavarian mineral collections of which he was made custodian. Under Groth's leadership the Mineralogisches Institut of the University of Munich became one of the chief centers for crystallographic and mineralogical study, advanced students being attracted from all over the world, particularly from the United States.

During his professorship at Munich Professor Groth stimulated and supervised many investigations dealing with various phases of crystallography and mineralogy. He also continued to write text and reference books and 13 additional volumes were placed to his credit of which only the following will be mentioned: *Grundriss der Edelstein-Kunde* (1887), the monumental work on *Chemische Kristallographie* in six volumes (1904 to 1919), *Elemente der physikalischen und chemischen Kristallographie* (1921), and *Die Entwicklungsgeschichte der mineralogischen Wissenschaften* (1926). The last book was published after his retirement from active teaching and when he had all but lost his eyesight.

Professor Groth's contributions to the mineralogical sciences were widely and most favorably recognized for he was elected to honorary membership in many learned societies. Since he had had many students from the United States and Canada it, indeed, was fitting that he should have been elected an honorary life fellow of the Mineralogical Society of America in 1926. Promi-

nent universities also gladly testified to Professor Groth's pre-eminent position among the world's leading scientists of his period, the Universities of Cambridge and Geneva having conferred upon him the honorary degree of doctor of science and the University of Prague that of doctor of philosophy.

Professor Groth's activities were so varied and many of his contributions so fundamental and far reaching that they exercised a profound influence not only upon the development of mineralogy but also upon certain phases of chemistry and physics. Accordingly many of his views on morphotrophy and isomorphism, and on chemical crystallography in general have become firmly embodied in chemical literature. Furthermore, the remarkable advances in our knowledge of crystal structure as the result of the development of X-ray analysis, dating from 1912, are in large measure due to Groth's long and enthusiastic advocacy of the point system theory of crystal structure.

Until the very last Professor Groth was keenly interested in American mineralogy. In 1893 he came to the United States and served as a member of the jury of awards for the division of Mines and Minerals of the World's Exposition held in Chicago that year. While in this country he visited some of our leading universities, museums, and mining and mineral localities.

In March 1926 I was privileged to visit Professor Groth twice in his home in Munich. Although he was then in his 83rd year and nearly blind, he displayed the same enthusiasm for his beloved science and still retained the alertness of mind that had attracted so many students to him and inspired them to achievement. At that time he eagerly inquired about his friends and former students in this country and Canada. He also expressed great pleasure in the progress made by the Mineralogical Society of America, for he followed its development with deep satisfaction.

During the 60 years of Groth's activity crystallography has passed by various stages of development from the list of the more or less descriptive sciences to that of the exact sciences permitting of precise measurements. To this advance Professor Groth and his many students contributed in no small measure.



## MEMORIAL OF GEORGE VAUX, JR.\*

SAMUEL G. GORDON, *Academy of Natural Science of Philadelphia.*

On October 24th, 1927, the members of this Society were saddened to learn of the death, early that morning, of George Vaux, Jr. Distinguished for his educational, scientific, benevolent and philanthropic activities, the Society has suffered a great loss. Even more keenly do we personally feel the absence of a friend, whose charm of manner, enthusiasm, and good fellowship endeared him to all his intimates.

George Vaux, Jr., was born in Philadelphia, on December 18, 1863, the son of George and Sarah (Morris) Vaux. He was the ninth of the family, in practically straight succession, to



GEORGE VAUX, JR.  
1863-1927

bear that name. The first George was deprived of his property at the restoration of Charles II after Cromwell's death in 1661,—perhaps because he was a Quaker, and therefore a Dissenter. His son, the second to bear the name, was born in 1640 in Essex County, England, and was followed by three more Georges, who were physicians in Reigate and London.

The fifth George Vaux, was born in 1721 and died in 1803. He had three sons, James, Richard, and George. The latter died, and the other two brothers came to Philadelphia. James

\* Memorial read at the eighth annual meeting of *The Mineralogical Society of America*, Cleveland, Ohio, December 29, 1927.

bought a "plantation" in 1771 directly across the Schuylkill River from Valley Forge, and perpetuated the family name in his son George, the seventh. The seventh George was a prominent lawyer in Philadelphia, and one of the founders of the Horticultural Society. His son married Sarah Morris, of Harriton (originally called Bryn Mawr, after an old farm house in Wales; the name was later transferred to the town).

On his mother's side, George Vaux, Jr., was descended from Thomas Lloyd, an early Colonial Governor, and Dr. Thomas Wynne, physician and friend of William Penn.

Mr. Vaux graduated from Haverford College in 1884, and from the Law School of the University of Pennsylvania in 1888. He was admitted to the bar that same year. He entered the law office of Pemberton Morris, where he was associated with Effingham B. Morris.

In the summer of 1887, he first visited the Canadian Rockies, in company with his father, brother (William S. Vaux, Jr.), and sister (Mrs. Charles D. Walcott). Many seasons in later years were devoted to the exploration of the mountains and studies of the glaciers, the results of which were embodied in five papers, illustrated with maps and superb photographs.

It was at Lake Louise that he first met Mary W. James, of Concord, Mass., who became his wife on April 2, 1907. Mrs. Vaux is the daughter of Robertson James, and niece of the late Henry James, the novelist, and Dr. William James, the noted psychologist.

As a member of the Society of Friends, Mr. Vaux Jr., worked assiduously in its service and held several responsible positions. He was on the Committee for the Revision of Discipline, the Friend's book of Faith and Practice. For a number of years he was President of the Friend's Historical Society.

While he was a member of a number of scientific organizations such as the American Philosophical Society, the American Association for the Advancement of Science, the Mineralogical Society (Great Britain), and the Mineralogical Society of America (of which he was vice-president in 1926), it was as an official of the Academy of Natural Sciences, and of the Philadelphia Mineralogical Society, that his scientific endeavors were especially noteworthy.

Mr. Vaux Jr., was elected a member of the Academy of Natural Sciences on October 25, 1892. In 1894 he was elected Treasurer,

and in 1911, Solicitor of the Academy, serving also as a member of the Council, and of the Board of Trustees. Through his skillfull management the Academy obtained a disputed bequest which doubled the income available for research.

His advice was frequently sought when purchasing specimens for the William S. Vaux Collection of the Academy, and his friendly criticism and aid were of great value in bringing the exhibits up to their present attractive state.

He was deeply interested in the development of the Department of Mineralogy of the Academy, and frequently contributed the means by which its work and researches were carried on. His cooperation made possible the expeditions sent to the Andes of Ecuador, Peru, Bolivia, and Chile in 1921; to Greenland in 1923, and to Bolivia and Chile in 1925. These trips were very successful not only in the number of fine specimens obtained, but in scientific results as well, which included the discovery of eight new minerals.

It was fitting, therefore, that the beautiful blue, hydrous iron and aluminum phosphate from the tin mines of Llallagua, Bolivia, should be named Vauxite in his honor. Related minerals received the names paravauxite, and metavauxite.

In 1922, Mr. Vaux Jr., was elected President of the Philadelphia Mineralogical Society. He was reelected to this office for the fifth consecutive term on October 26, 1927. On this occasion he addressed the Thirty-fifth Anniversary meeting of the Society, and spoke on "1892-1927: A Retrospect and Some Comments on the Future."

His long experience as a mineralogist made his counsel invaluable, and his enthusiam was a splendid inspiration to the members. His pleasing personality and ready wit made him an ideal presiding officer.

To most mineralogists, George Vaux, Jr., was best known through the magnificent collection of minerals he had assembled. Due to his enthusiasm he had accumulated approximately 10,000 specimens, including 850 species. He regarded the science of mineralogy as "The most delightful of pastimes, . . . one of the most fascinating subjects to which one can devote himself." It was a surprise to him that more persons were not interested in this science.



Mr. Vaux Jr., began collecting while still a young boy. He became acquainted with the collection of his uncle, William S. Vaux, at that time the finest mineral collection in America; and had the pleasure of associating with the naturalists who met at their house on Saturday afternoons. It is of interest to note that it was his grand-uncle, Joseph Sansom (1767-1826) who brought together one of the first mineral collections in America, which was later given to Haverford College. When George was 19 years old his uncle, William Vaux, died, and the collection was bequeathed to the Academy, with a fund of \$10,000 to maintain it. The family was given the privilege of retaining twenty-five specimens.

The collection of George Vaux, Jr., grew rapidly in the course of years, as he realized that the opportunity of acquiring good specimens was limited and it was his endeavor to obtain the best specimens available.

In 1910 he built a beautiful Colonial house at Bryn Mawr, and shortly after, a large fire-proof extension, for his mineral collection.

In the center of the room is the treasured desk about which the friends of his uncle, William S. Vaux, gathered to examine minerals in the days of his youth. To the right, on a cabinet stands a small upright case with a glass front concealed by a wooden shutter. This contains the twenty-five specimens, including the marvelous proustites, which were collected by his uncle. Abutting the windows are twelve drawer-cabinets, and four vertical cases with glass fronts which contain the larger and showier minerals. Most of the specimens are in cardboard trays in drawers. Each is carefully labeled and tastefully arranged; individual crystals being mounted on stands to display them to best advantage.

Perhaps the most characteristic feature of the collection was the development of suites, it having been his endeavor to obtain as complete a series of fine specimens of each mineral as possible. Mineralogists will readily recollect the impressions received upon seeing the drawers of Joplin golden calcite, Tsumeb azurite, and Vöröspatak gold, specimens of unrivaled perfection, beauty of color, and variety of form.

The French Creek mines, being but an hour's drive by automobile from his house, were frequently visited, and his col-

lection was enriched by many fine specimens from this locality. He had prepared, shortly before his death, an article on this district for the *American Mineralogist*.<sup>1</sup> A visit to Franklin in 1922 resulted in the acquisition of some very fine specimens, the pick of one of the local collections.

Mr. Vaux was much interested in education, and was a member of the Board of Managers of Carson College, Haverford College, and the Wistar Institute of the University of Pennsylvania; a director of the Cheyney School for Teachers, and a member of the Committee of the Westtown School and the Friend's Select School.

In 1906, President Roosevelt appointed him a member of the Board of Indian Commissioners, and he served as chairman of this Board from 1907 until his death. He gained a wide knowledge of the life, customs, and general affairs of the American Indian by personal contact with them, making especial studies of the Sioux of South Dakota, the Quapaw, Osage and the Five Civilized Tribes of Oklahoma; the Papago, Pima, Apache, Hopi, and Navajo of Arizona; the Pueblo of New Mexico; and the Mission Indians of Southern California.

It was largely due to his efforts that the Geronimo band of Apaches, who had been held prisoners of war at Fort Sill, Oklahoma, were released, and apportioned to lands in western Oklahoma, and southern New Mexico. As a result of recommendations embodied in his reports, many remedial changes were made in the Federal administration of Indian affairs.

With the beautiful simplicity of the Society of Friends, he was laid away in the Harriton family plot: sequestered in the extensive oak groves of his Bryn Mawr estate, the resting place of his ancestors for over two hundred years.

He is survived by his widow, and two sons, George and Henry James, and his sister, Mrs. Charles D. Walcott.

#### PUBLICATIONS

Vaux, George, Jr. Some unusual quartz pseudomorphs from the Hopewell Mine, Warwick Township, Chester County, Pennsylvania. *Acad. Nat. Sciences, Phila., Proceedings*, 1926, page 17.

The mines at the Falls of French Creek, Chester County, Pennsylvania. *Am. Mineral.* 13, 25 (1928).

<sup>1</sup> *Am. Mineral.*, 13, 25 (1928).

Present tendencies in mineralogical science. From an address on the occasion of the 35th Anniversary meeting of the Philadelphia Mineralogical Society, October 6th, 1927. To be published in the Yearbook of the *Academy of Natural Sciences*.

Vaux, George, Jr. and William, Jr. Some observations on the Illecillewaet and Asulkan glaciers of British Columbia; *Acad. Nat. Sci., Phila., Proceedings*, 1899, p. 121.

Additional observations on glaciers in British Columbia; *ibid.*, 1899, p. 501.

Observations made in 1900 on glaciers in British Columbia; *ibid.*, 1901, p. 213.

Observations made in 1906 on glaciers in Alberta and British Columbia; *ibid.*, 1906, p. 568.

Observations made in 1907 on glaciers in Alberta and British Columbia; *ibid.*, 1907, p. 560.



## MEMORIAL TO JOSÉ J. BRAVO\*

L. GARCIA.

Dr. Bravo was born in the city of Lima, the capital of Peru, on the 17th of April, 1874. His parents were Dr. Manuel Gerardo Bravo and Señora Maria Bresani, both of illustrious lineage, and he was a grandson of the famous Peruvian physician, Dr. José Julian Bravo.

He received his elementary education in the Institute of Lima, where he always received the highest honors. Then he went to the engineering school whose halls witnessed his talent, his successes and his scholarship which was of the highest order. He closed his scholastic career at the age of twenty, after which followed a life of activity and study, he being one of the most intellectual collaborators in the National development, and an exponent of its potentialities, himself giving an example of unremitting labor in the various fields of science and professional work, and dedicating himself unreservedly to science and his country.

He introduced into the country the study of micropetrography and modernized the teaching of mineralogy, and wrote the first course in palaeontology printed in South America. He recognized that the mineral deposits of Pallasca and Conchucó, considered up to that time as iron mines of no value, contained the rare and valuable mineral wolframite. He was the first engineer to declare that the deposits of vanadium at Minas Ragra were the most important in the world. He had the distinction of having the name Bravoite given to a mineral discovered by him. He also discovered two species new to science, Patronite and Helectypus Paulckey. Bravo was the directing spirit in the National Congress of Mines in 1917, as also in the Pan American Scientific Congress in 1924, of which he was General Secretary. Simultaneously with the Scientific Congress was held the Congress on the Unification of Specifications in which he took a conspicuous part and as a consequence was appointed a director in the bureau established at Lima.

\* Paper read by Professor A. L. Parsons at the eighth annual meeting of *The Mineralogical Society of America*, Cleveland, Ohio, December 29, 1927.

Bravo was an Engineer, Doctor of Science, and Professor of the University of San Marcos where he offered a course in Physical Geography, the lectures of which have been printed.

He solved the difficult problem of the fumes at Arroya. As an official he collaborated in various administrative and government undertakings, some of which were outside his official sphere of action, a notable example of this being his work on export laws.

He was the Director of the Cuerpo de Ingenieros de Minas y Aguas, Director of the Bureau of Standards, President of the Association for the Advancement of Science, a member of the Supreme Council for Mines and Waters, Professor in the School of Engineering, offering courses in palaeontology and mineralogy. He was a member of the Societies of Mines, Engineers, Geology and Geography, the Council of Industrial and Scientific Research, the Geodetic and Geophysics Union, the Technical Committee on Taxation, Protector of the Indigenous Race, occupying on many occasions the Presidency of many of them.

In 1908 the Provincial Council of Lima in honor of his studies on mineralogy, micropetrography and palaeontology, decorated him with a gold medal and he also received decorations from the Crown of Italy, the Holy See and others. He was a member of many scientific institutions of Europe and North America, among which are the following: Deutsche Geologische Gesellschaft, The Mineralogical Engineers, Société Géologique de France, The Institution of Petroleum Technologists (London), American Geographical Society (New York), Société Linnéene de Lyon, and the Mineralogical Society of America.

His publications include the following books: Mineralogy, Palaeontology, Physical Geography and various works and studies of great importance.

He was overtaken by death on a visit to the United States to represent Peru at the Congress of Standards and Commerce which met at Washington, planning to continue his journey to Europe to take part in the Congress of Geodesy and Geophysics.

An automobile travelling at thirty-five miles per hour took his life, leaving as orphans his little children. Dr. Bravo was married to Señora Sara Bresani who had died scarcely a year before.

# PROCEEDINGS OF THE EIGHTH ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA

FRANK R. VAN HORN, *Secretary*.

The Mineralogical Society of America held its eighth annual meeting on December 29, 30, and 31, 1927, in conjunction with the Geological Society of America at Cleveland, Ohio, as guests of Case School of Applied Science and Western Reserve University. On Thursday, December 29, at 2:00 P.M. President A. F. Rogers called the regular annual meeting to order in the Geology-Mineralogy Lecture Room of Case Main Building. On motion of the Secretary the reading of the minutes of the last annual meeting was dispensed with, in view of the fact that they have been printed on pages 71-83 of Volume 12 (Number 3) of *THE AMERICAN MINERALOGIST*.

## ELECTION OF OFFICERS AND FELLOWS FOR 1927

The Secretary announced that 142 ballots had been cast for the officers as nominated by the Council. Of these 139 were unanimous and three were negative in part. For fellows there was an unanimous vote of 61 ballots in the affirmative. All officers and fellows were declared elected.

The officers elected for 1928 are the following:

*President*: Esper S. Larsen, Harvard University, Cambridge, Mass.

*Vice-President*: Lazard Cahn, Colorado Springs, Colorado.

*Secretary*: Frank R. Van Horn, Case School of Applied Science, Cleveland, Ohio.

*Treasurer*: Alexander H. Phillips, Princeton University, Princeton, New Jersey.

*Editor*: Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.

*Councilor 1928-1931*: Ellis Thompson, University of Toronto, Toronto, Canada.

The fellows elected follow:

Arthur Hutchinson, University of Cambridge, Cambridge, England.

Robert L. Parker, Swiss Federal Technical University, Zurich, Switzerland.

Lewis S. Ramsdell, University of Michigan, Ann Arbor, Michigan.

Hans Schneiderhoehn, University of Freiburg, Baden, Germany.

Chester B. Slawson, University of Michigan, Ann Arbor, Michigan.

A. J. Walcott, Northwestern University, Evanston, Illinois.

## REPORT OF THE SECRETARY FOR 1927

*To the Council of the Mineralogical Society of America*: The Secretary herewith begs to report that the roll of the Society now comprises 105 fellows and 218 members, a gain of 2 fellows and 13 members for the year notwithstanding the fact that 2 fellows and 14 members have been dropped from the mailing list for nonpayment of dues. One honorary fellow, Professor Paul von Groth, and one fellow, George Vaux, Jr., have died. Brief accounts of their careers appear in this issue of the Journal. Three members, Professor José J. Bravo, J. H. Ten Eyck Burr, and Henry Fair, have also died. In addition to the 323 fellows and members, there are 163 subscribers, a gain of 12 for the year although 8 were dropped for nonpayment. A total of 476 paid copies of the Journal are mailed monthly, an increase of 17 over last year. Actually, during the past year, 5 fellows, 39 members and 8 subscribers were added, but the net gain was not large, due to deaths, resignations, and non-payment of dues and subscriptions.

Respectfully submitted,

FRANK R. VAN HORN, *Secretary*.



## REPORT OF THE TREASURER FOR 1927

The Treasurer read his report, and on motion it was accepted and ordered filed. On motion an auditing committee composed of non-members of the Council was appointed by the President. This committee consisted of Charles Palache and R. J. Colony, and later reported to the Secretary that they found the books of the Treasurer correct.

*To the Council of the Mineralogical Society of America:* Your treasurer herewith submits his annual report for the year ending November 30, 1927:

## RECEIPTS

Cash on hand December 1, 1926. . . . .	\$2,704.37	
Dues and subscriptions. . . . .	1,705.62	
Advertisements. . . . .	279.25	
Sale of back numbers. . . . .	508.69	
Interest on bank deposits and Endowment. . . . .	2,338.92	
Miscellaneous. . . . .	23.47	
	<hr/>	\$7,560.32

## DISBURSEMENTS

Printing and distribution of the Journal. . . . .	\$2,859.28	
Printing of Vols. 1-5 and Decennial Index. . . . .	1,047.82	
Miscellaneous printing, stationery, and postage. . . . .	28.82	
To the Editor. . . . .	375.00	
Miscellaneous. . . . .	38.79	
	<hr/>	\$4,349.71
BALANCE in Princeton Bank & Trust Co., Nov. 30, 1927. . . . .	3,210.61	\$7,560.32
The Endowment consists of 45 one thousand dollar bonds of the City and County of Honolulu. . . . .	\$45,000.00	
4 Liberty Bonds of \$100 each 4th 4- $\frac{1}{4}$ % . . . . .	400.00	
3 \$100 bonds of the Great Northern R.R., 5- $\frac{1}{2}$ % Gold. . . . .	300.00	
	<hr/>	\$45,700.00

Respectfully submitted,  
ALEXANDER H. PHILLIPS, *Treasurer.*

## REPORT OF THE EDITOR FOR 1927

The report was read by the Editor, and on motion it was accepted and ordered filed.

*To the Council of The Mineralogical Society of America:* In the Editor's report a year ago several recommendations were made to the Council which seemed to represent very desirable undertakings. These recommendations included the preparation of an author-subject decennial index covering the period 1916-1925 and the printing, by photographic process, of the first five volumes of the Journal. The Council very generously authorized the necessary expenditures and the current year has seen these two projects completed.

The need for reprinting these early volumes had been felt for some time and the sale of these, and subsequent issues which the early volumes now make possible, will more than repay in a short time the original expenditure. This statement is based upon an item in the treasurer's present report which shows a sale of back numbers during the year of over \$500 compared with \$250 of a year ago. This is a very creditable showing considering that the reprinted volumes were not available for distribution until June and that the treasurer's report does not include sales made during the month of December.

The decennial index is moving more slowly. An edition of 600 was printed to insure an ample supply for both present and future needs as it seems reasonable to believe that there will always be a limited but steady demand for such an index from those using the Journal for reference purposes.

In attempting an analysis of the Journal for the current year we find that the volume for 1927 contains approximately 450 pages of text proper, a volume which in size has been equalled but once in the history of the Society. One special number containing ten contributions from the Department of Mineralogy & Petrography of Harvard University contributed 90 pages towards this total. As has been the custom in former years the Society's share of the cost of this special number was approximately the same as for a normal issue. The readers were thus enabled to secure an unusually large and attractive volume without undue strain being placed upon the treasury. It is quite possible that the issues for the coming year will again include at least one special number.

The current issue contains 60 *leading* articles, or an average of five articles per month, and represents contributions received from 27 different Universities and research Bureaus. The number of leading articles establishes a new record and is especially gratifying as it includes nine manuscripts sent in from outside of the States—one each from Germany, Bohemia and Italy and six from Canada—clearly indicating a growing cosmopolitan interest in the Society's publication.

Of the 60 leading articles, 7 recorded for the first time descriptions of new mineral species; 10 described famous mineral localities; 29 called attention to new data on established species and 14 consisted of addresses, memorials and articles of a miscellaneous character. The series of mineral locality articles, which was begun over a year ago, should appeal particularly to our friends the collectors and will be continued from time to time as suitable material becomes available. Issues now in press contain brief descriptions of the mines at the Falls of French Creek, Pennsylvania, and the minerals in the Black Hills district, South Dakota.

The 60 leading articles of the present year occupied 359 pages or 81.5 per cent of the total space, while 14 book reviews, 20 reports of the proceedings of societies, 45 abstracted accounts of new mineral names and 59 other items of general interest, including brief discussions, filled the remaining 81 pages or 18.5 per cent of the space of the Journal.

In regard to plans for the coming year, inasmuch as two items on this year's list—printing of volumes 1-5 and the index—are not recurrent expenditures, the saving here would permit further expansion of the Journal if the manuscripts are forth coming. Letters sent out each year seeking information as to the location of desirable material is proof that difficulty is still experienced in completing well balanced issues during the summer months. As very little material is received during the vacation period the stock on hand, at times, becomes uncomfortably low.

The only solution seems to be to increase the reserve supply sufficiently during the spring and early summer to carry the Journal over this lean period. May I suggest, therefore, that special effort be made to complete all unfinished manuscripts and that they be turned in before leaving for your summer's work.

One other matter the Council might well consider although no definite action need be taken at this time. Frequently inquiries are received asking when the present policy of the Society would be changed from one granting contributors 25 complete issues of the Journal to one of issuing a limited number of reprints instead. The present system is less expensive to the Society but less convenient to the contributor who maintains an exchange list. No change in the present method is advocated until the amount of this extra expense can be fairly definitely stated. That is impossible at the present moment. I believe, however, that it is a desirable goal and should be reached as soon as possible.

The concluding table of contents summarizes the distribution of subject matter in volume 12.

#### DISTRIBUTION OF SUBJECT MATTER IN VOLUME 12

<i>Subjects</i>	<i>Articles</i>	<i>Pages</i>	<i>Percent. of total</i>
Original articles			
New mineral species	7		
Mineral locality articles	10		
New data on established species	29		
Memorials, addresses, etc.	14		
	60	359	81.5
Proceedings of societies	20	32½	18.5
Notes and news	59	23½	
Book reviews	14	11	
Abstracted accounts of new mineral names	45	14	
Total of text	198	440	100.0
Illustrations	119		
Covers, advertisements, index		92	
Total		532	

Respectfully submitted,  
WALTER F. HUNT, *Editor*.

#### REPORT OF THE COMMITTEE ON NOMENCLATURE AND CLASSIFICATION OF MINERALS

W. F. Foshag reported that the committee had held no meetings during the past year. It was moved and carried that the committee be continued. This committee consists of H. S. Washington, W. F. Foshag, A. F. Rogers, T. L. Walker, E. T. Wherry, and E. S. Larsen.



REPORT OF THE COMMITTEE ON PRESERVATION  
OF TYPE MATERIAL

W. T. Schaller, chairman, reported progress. It was moved and carried to accept the report and continue the committee which consists of W. T. Schaller, W. F. Foshag, H. P. Whitlock, A. N. Winchell, and A. L. Parsons.

## NEW BUSINESS

It was moved, seconded and carried that the Council send congratulations and the good wishes of the Society to Professor Victor Goldschmidt, Heidelberg, Germany, on his approaching 75th birthday.

The question of the number of reprints to be given the authors of leading articles was discussed. It was moved and carried that the Council consider some plan which would be more acceptable to the authors. It was suggested that 50 copies without covers would be more acceptable than the present policy.

Dr. T. L. Walker mentioned the possibility of having a Mineralogical Section at the next International Geological Congress.

## MEMORIAL BIOGRAPHIES

A memorial sketch of Professor Paul von Groth was read by Edward H. Kraus. A memorial of George Vaux, Jr., written by S. G. Gordon was read by Frank R. Van Horn. A biography of Professor J. J. Bravo of Lima, Peru, was read by A. L. Parsons. Professor Bravo was nominated by the Council for fellowship but was killed in an automobile accident at Akron, Ohio, before his election. These memorials are printed in full in this issue.

## PRESENTATION OF PAPERS

At 3:00 P.M., there being no further business, the Society proceeded to the reading of scientific papers. The papers presented with short abstracts follow.

K. K. LANDES: *Sequence of Mineralization in Keystone, South Dakota Pegmatites*. Pegmatites described are the Etta, Hugo, Peerless, and Ingersoll. In all of these the common minerals quartz, feldspar (orthoclase, microcline, or perthite), and muscovite crystallized out during an early magmatic phase. The less common minerals such as albite (variety cleavelandite), lepidolite, cassiterite, spodumene, columbite and many others replace the earlier minerals and were deposited by solutions from portions of the pegmatite still in process of consolidation. In some instances these hydrothermal minerals make definite veins through minerals deposited at an earlier stage.

J. T. LONSDALE: *Analcite from Brewster County, Texas*. This paper describes the occurrence of the first find of analcite from Texas. The crystal and optical properties of the mineral are given along with a chemical analysis.

A. N. WINCHELL: *The Isomorphous Relations of  $MgSiO_3$  and  $AlAlO_3$  in Silicates*. The evidence that  $AlAlO_3$  may replace or "proxy for"  $MgSiO_3$  in silicates is summarized with special reference to the case of muscovite.

\* \* \* \*

At 3:45 P.M. the Society adjourned to attend a joint session in the Physics Lecture Room, Case School of Applied Science, with the Geological Society of

America before which the presidential address of Professor Austin F. Rogers on "*The Natural History of the Silica Minerals*" was given. This paper is published in full in this number. Following this address with A. F. Rogers presiding, papers of a mineralogical and petrographical nature were presented. The joint session adjourned at 6:00 P.M.

On Friday, December 30, at 9:15 A.M., President Rogers called the second session of the Society to order in the Geology-Mineralogy Lecture Room of the Case Main Building, and the reading of papers proceeded according to program.

G. AMINOFF and A. L. PARSONS: *Crystal Structure of Sperrylite*. Sperrylite has a simple cubic lattice. The length of the cube edge is 6.00Å. There are four molecules in the unit cube. Position of the atoms, Pt. 4b, As. 8h. This type of structure is the same as that found in pyrite. The value 5.40Å was determined for the cube edge of pyrite.

D. E. KERR-LAWSON (introduced by T. L. WALKER): *Pleochroic Haloes in Biotite*. Examination of pleochroic haloes in a biotite probably of Precambrian age, from near Murray Bay, Quebec, shows (1) that the haloes are distributed along the major and minor cleavage planes in such a way as to suggest that the minute radioactive nuclei were introduced after the crystallization of the biotite, (2) that a halo consists of a series of concentric spherical shells of different color density, (3) that the structure of a halo can only be properly seen where the thickness of the section is small compared with the diameter of the halo, (4) that the light-absorption curve obtained across a diameter of a thin halo-section by means of a microphotometer shows a remarkable similarity to the composite ionization curve for the eight alpha particles from the uranium series, and does not suggest that this curve might have been different in geologically ancient times, (5) where two haloes overlap, they interpenetrate in a curious way, so that where a light-colored shell of one halo cuts a dark colored shell of another, the dark shell is rendered lighter.

C. S. ROSS and P. F. KERR: *Optical and X-Ray Research on Clay Minerals*. A continuation of studies of the optical, chemical and x-ray properties of the clay minerals has tended to confirm the validity of some of the doubtful species, but it indicates that others have received more than one name. The work to date has tended to reduce the number of valid species. The following minerals have been investigated: kaolinite, halloysite, beidellite, nontronite, montmorillonite, anauxite, leverrierite, indianite, lenzenite, collyrite, glagerite, and saponite.

C. S. ROSS, E. V. SHANNON, and F. A. GONYER: *The Formation of Nickel Silicates by Base Exchange*. The weathering of the Webster, North Carolina, dunite has released the nickel that was originally a sparse constituent of the silicate minerals, principally the olivine, and is now concentrated in veins of nickel silicates. The mineralogy of the veins, however, is identical with that of non-nickel-bearing veins that are widely distributed in dunite and serpentine masses. The geological relations therefore indicate that few new minerals have been formed, but most of the nickel has been transferred from dunite to previously existing vein minerals by the process of base exchange during weathering. The possibility of base exchange is confirmed by experiment.

W. T. SCHALLER: *Occurrence of Kernite and Associated Borates*. An enormous quantity of kernite is present several hundred feet underground near Kramer, Mojave desert, Calif. Crystals measuring up to 6 by 3 feet, irregular masses, and veins occur in mud shales. Massive rock borax and several other borates are relatively sparingly present.

W. T. SCHALLER: *Probable Identity of Camsellite with Szaibelyite*. A comparison of the optical properties and analyses of these two minerals shows such similarity that they are probably identical.

W. T. SCHALLER: *Potash Minerals from the Texas-New Mexico Field*. Study of drill cores from 3 wells has identified the following potash minerals from this saline field: sylvite, polyhalite, carnallite, kainite, and langbeinite.

W. T. SCHALLER: *Base Exchange in Artificial Autunites*. Starting with artificially prepared autunite, definite crystalline compounds were made in which sodium, potassium, barium, manganese, or lead proxied for calcium. The soda, in artificial sodium autunite, was readily replaced by potassium, barium, and manganese.

O. F. POINDEXTER: *Constituents of Diamond-bearing Black Sands from Angola, Portugese West Africa*. (Paper presented by Frank R. Van Horn). The following minerals are present: diamond, corundum, tourmaline, staurolite, hornblende, zircon, rutile, garnet, cyanite, diallage, quartz, ilmenite, hematite and pyrite. Also possibly spinel, columbite, topaz, beryl, moonstone, opal, chalcedony. A black glassy mineral resembling in luster obsidian is also present. Hardness 6.5, sp. gr. 3.70. Biaxial, positive.  $\beta = 1.75$ , brownish, pleochroic. No analysis was made but believed to be a variety of augite.

C. S. ROSS: *Sedimentary Analcite in Arizona*. A fine grained sandstone-like material from western Arizona proved to be made up almost exclusively of small trapezohedrons, and the optical and chemical properties show the crystals to be analcite. The analcite forms beds in fine grained sediments of the playa type and are clearly part of a sedimentary series. It is evident, therefore, that analcite may be formed either by direct chemical precipitation or more probably by the reaction between concentrated alkaline solutions and colloidal clay material.

E. K. GEDNEY: *A New Method for the Determination of the Feldspars*. A short and accurate method for determining any feldspar is possible by comparing the spectrophotographs of unknown with those of known specimens. At the present stage of research this comparison also assures a quantitative analysis within one-half percent. of error, not only of the lime-soda content, but also of other alkalis, alkaline earths, and aluminum.

E. K. GEDNEY and C. W. BROWN: *Some New Occurrences of Rare Metal and other Minerals from the Cumberland Region of Rhode Island*. Over eighty distinct species with many varieties have been determined from this small but complex region. The area is marked by a widespread occurrence of rare metal minerals, such as eudialyte and titano-columbates of the rare earths, of a pronounced pneumatolytic and metasomatic origin.

W. A. TARR: *Doubly Terminated Quartz Crystals in Gypsum from Acme, New Mexico*. Splendidly developed doubly terminated crystals were found in a specimen of massive gypsum near Acme, New Mexico. The specimen was found on the outcrop of the gypsum but not in place. The quartz crystals range from a fraction of a millimeter up to an inch in length. All but the smallest are pink or red in color. The rhombohedral faces are well developed, but the prismatic faces are rough. The quartz crystals occur in a band two inches thick, having replaced the gypsum.

\* \* \* \*

At 12:40 P.M. the Society adjourned for lunch. At 2:10 P.M., President Rogers called the third session to order, and immediately proceeded with the final papers on the program.

J. W. GRUNER: *A Preliminary Report of the Crystal Structure of Analcite*. The Laue, powder and oscillation methods were used in investigation of the structure of analcite. In spite of the anomalies of the mineral which cast some doubt on its cubic character, it was impossible to find lower symmetry with the aid of X-rays. The lattice is cubic holohedral body-centered. The edge of the unit cube is  $13.64 \pm 0.05 \text{ \AA}$  long. Each unit cube contains sixteen molecules  $\text{NaAlSi}_2\text{O}_6 \cdot \text{H}_2\text{O}$ . The space group is  $\text{O}_h^9(\text{O}_i-9, \text{Wyckoff})$ . Analcite dehydrated at  $600^\circ$  to  $700^\circ$  shows very little change in volume. The structure seems also to remain the same. Obviously the loss of the water has little influence on the arrangement of the atoms or ions in analcite.

F. R. VAN HORN: *Large Magnetite and Franklinite Crystals from Franklin Furnace, New Jersey*. In 1893 when visiting Franklin, a large crystal of magnetite was found which weighed 1205 grams. It is about  $9 \times 9 \times 10$  centimeters or  $3\frac{1}{2} \times 3\frac{1}{2} \times 4$  inches in size, and of rhombic dodecahedral habit with a small octahedron. The size is very unusual. In 1891 a large crystal of franklinite associated with zincite, tephroite and calcite was found which weighed 975 grams. The habit is octahedral with a small rhombic dodecahedron, the longest face of which is about 10 centimeters or 4 inches in length. A second specimen was found in 1893 consisting of a group of two crystals, the larger of which is about 8 centimeters or  $3\frac{1}{2}$  inches long. Larger franklinite crystals have probably been found, but specimens of these dimensions are quite unusual.

E. S. LARSEN: *Mineralogical Data on the Humite Group*. The optical properties of the various members of the humite group studied by Brush and by Sjogren have been determined and give the following values for the members.

	$\alpha$	$\beta$	$\gamma$	Ext.	2V	Disp.
Norbergite	1.568	1.572	1.588	0	med. large	$\rho > \nu$
Chondrodite	1.605	1.618	1.636	$27^\circ$	large to over $90^\circ$	$\rho > \nu$
Humite	1.622	1.632	1.652	0	med. large	$\rho < \nu$
Clinohumite {	1.623	1.636	1.651	7 to	large	$\rho < \nu$
	1.652	1.663	1.681	$15^\circ$		

In general the chondrodites show little variation in the values of their indices of refraction but the Tilly Foster mineral has much higher indices ( $\beta = 1.638$  to  $1.655$ ) with no chemical difference that would explain the high values.



For humite the Nordmarken mineral has  $\beta = 1.643$ , but this high value is probably due to the high iron content. ( $\text{FeO} + \text{Fe}_2\text{O}_3 + \text{MnO} = 10.68$ ).

Clinohumite from Nordmark has  $\beta = 1.663$  and high iron ( $\text{FeO} + \text{MnO} = 15.44$ ), and the titanohydroclinohumite from Italy has  $\beta = 1.673$  with moderate iron ( $\text{FeO} + \text{Fe}_2\text{O}_3 + \text{MnO} = 5.6$ ), low F (0.03), high  $\text{TiO}_2$  (1.92), and high  $\text{H}_2\text{O}$  (3.16).

Norbergite has been found in abundance at Franklin Furnace and it is orthorhombic in symmetry, the crystals resembling those of humite.

CHARLES PALACHE and MARTIN A. PEACOCK: *Nature and Origin of the Amphibole-Asbestos of South Africa*. The study is based on a series of specimens of asbestos-bearing ironstones from Cape Province and the Transvaal, collected by the senior author on the Shaler Memorial Expedition to South Africa in 1922. Crocidolite and amosite occur in these rocks in persistent, interbedded, cross-fiber seams. On the basis of optical and chemical study of favorable material the data of these minerals have been revised and extended. In the genetic discussion the following have been treated: the origin of the iron stones; the sources of the constituents of the asbestos seams; the conditions which promoted the formation of asbestos; and the special conditions which determined cross-fiber structure. Seven new analyses are contributed.

CHARLES PALACHE: *Mineralogical Notes on Franklin Furnace*. Notes compiled with the assistance of Messrs. L. H. Bauer, H. Berman and L. W. Lewis on the occurrence, composition, crystallography, and chemical properties of the following minerals: azurite, cahnite, clinozoisite, gageite, glaucocroite, hetaerolite, hodgkinsonite, quartz, smithsonite, sussexite, tephroite, tetrahedrite, and willemite.

LYMAN W. LEWIS: *The Paragenesis of the Granite Pegmatite of Fitchburg, Massachusetts*. (Read in abstract.) In the Fitchburg quarries persistent pegmatite dikes from an inch to over a foot in width have been injected along a conjugate system of fractures. The walls are clean cut in the field with a border of microcline on both contacts and a center filling of quartz against the crystal boundaries of the feldspar. The pegmatites consist essentially of microcline and quartz with subordinate black tourmaline, beryl, garnet and allanite. Evidence is presented to support the thesis that all the minerals in the pegmatite crystallized in the same late magmatic phase, and that reaction and replacement of early minerals is unimportant in the formation of these pegmatites.

LYMAN W. LEWIS: *The Calculation of the Interfacial Angles from Coordinate Elements in the Hexagonal System*. (Read in abstract.) Presentation of a method of expressing the relations between interfacial angles and polar elements with corresponding position angles in the hexagonal system, together with necessary formulas and examples.

L. H. BAUER and HARRY BERMAN: *Friedelite, Schallerite, and Related Minerals*. A reexamination of the friedelite-schallerite group and some intermediate members, of which there are new analyses available. Also an attempt to classify some related minerals as being members of a more extensive series to which friedelite, schallerite, pyrosmalite, and possibly dixenite, hematolite and the new Franklin mineral mcgovernite belong. The discussion is chiefly optical and chemical.

E. P. HENDERSON: *Uvarovite from California*. The analysis of this chromium garnet was made to confirm the variety uvarovite. Hasty search through the literature, shows few analyses with high chromium percentages; and in many cases the iron, aluminum and chromium were not separated. This garnet has sufficient chromium to confirm the existence of uvarovite as a variety.

E. P. HENDERSON: *Correlation of chemical composition and the optical properties of Triplite*. Triplite is a mineral whose chemical composition varies greatly. Some contain only small percentages of FeO (as low as 1.68%), others as high as 41.42% FeO. The optical values change as the percentage of FeO increases. It seems advisable to limit the name triplite to the manganese fluor-phosphate and give the name zwieselite to the iron fluor-phosphate. The name zwieselite is now in the literature as the iron rich variety of triplite. The calcium and magnesium present in the analysis can be accounted for by isomorphism, a mixture of the spodrosite and wagnerite molecules, respectively.

JOSEPH L. GILLSON: *Stages in the Contact Metamorphism in the Pend Oreille District of Northern Idaho*. The Pend Oreille district lies around the southern arm of Lake Pend Oreille, in northern Idaho. There, quartzites and argillites belonging to the Belt series of Algonkian age, and a Cambrian quartzite, shale and limestone have been intruded by Mesozoic granodiorites. The resulting metamorphism was intense and widespread. The exomorphism proceeded in three overlapping stages, as follows: 1. A recrystallization of the limestone to marble, and the quartzites and argillites to adinoles; a process caused by a general distillation of hot juvenile waters, carrying soda, during the intrusion of the magma. 2. A formation by metasomatism in the marbles and adinoles of a considerable variety of high-temperature silicates. These minerals formed after the intrusive rock was solid at the margin, but still very hot. 3. A replacement of these earlier minerals by muscovite, sericite, chlorite, magnetite, and pyrrhotite, and, in exceptional cases, by zeolites and carbonates. Only the third stage is represented in the endomorphism. Muscovite, sericite, chlorite, magnetite, and locally molybdenite and other sulphides and calcite formed in a progressive sequence in the solid granodiorite by solutions which seem to have ascended along the margins of the intrusive.

VICTOR GOLDSCHMIDT and S. G. GORDON: *Crystallographic Tables for the Determination of Minerals*. (Read in abstract). Tables have been prepared of 1025 species, and 193 important varieties and doubtful species. Of this number crystallographic data are available for 759 minerals, and these have been so arranged as to be convenient for the determination of a species by goniometric measurement.

S. G. GORDON: *The Convenience of a Rotating Table in the Use of the Two-circle Goniometer*. (Read in abstract). By mounting the Goldschmidt Two-circle goniometer on a rotating table, the apparatus can be turned to bring the vertical circle and horizontal circle successively in a position for comfortable reading of angles.

ALFRED C. HAWKINS: *Casts and Pseudomorphs of the Soluble Minerals in the Triassic Shales of Central New Jersey*. (Read in abstract). Cavities of glauberite in individual crystals and groups occur at Blackwells Mills, New Jersey, filled with calcite, which forms a pseudomorphous replacement. (In red shale). Similar glauberite cavities found at New Brunswick, New Jersey, contain small barite crystals

in addition to the calcite. Hopper-shaped cavities which were originally occupied by halite crystals occur near New Brunswick, New Jersey, in red shales. This is the first time that such halite cavities have been reported in the Triassic at any point south of New England.

M. N. SHORT: *Microchemical Determination of the Ore Minerals*. The identification of ore minerals in polished sections up to the present has been based on their appearance and upon certain etching effects brought about by a set of standard chemical reagents. The result of ten or more years' experience in applying these tests indicates that they are not entirely to be relied upon without confirmation by other methods. It is believed that qualitative microchemical tests for the elements in the minerals are the most reliable means of identification. This paper outlines the methods of applying such tests.

L. S. BROWN: (Introduced by J. T. Lonsdale). *Occurrence of Rutile, Ilmenite and Leucoxene in Mid-Continental Sediments*. Making some rather extensive investigations of so-called "heavy mineral" residues of Mid-Continent sediments (Permian red sandstones) it was found that approximately 70% of such residues from a bromoform separation consisted of leucoxene, ilmenite and rutile, the former predominating. Some of the characters observed include characteristic rutile and ilmenite structures and their survival in the leucoxene. Also alteration of rutile to leucoxene is demonstrated and attempts made to determine whether such alteration occurred prior or subsequent to disintegration of parent rock. A possible and probable explanation of the "pitting" of sedimentary leucoxene as described by Milner is discussed.

STEPHEN RICHARZ: *Stilbite from the Keweenawian Lavas of Northern Wisconsin*. Several hundred yards above the Copper Falls near Mellen in Northern Wisconsin, well developed stilbite crystals were found in a vein in the Keweenawian basic lavas, associated with calcite and quartz. It seems to be the mineral which was regarded by former geologists as laumontite. The refractive indices are considerably less than those of laumontite and even less than those observed heretofore for stilbite. The highest index is close to 1.490, compared with 1.500 in other occurrences of this zeolite. The axial angle is appreciably larger than in stilbite of most authors. Heating changes the optical orientation of the mineral.

LEWIS C. RAMSDELL: *The Crystal Structure of Cuprous Sulfide*. X-ray diffraction patterns of a cubic type can be secured by heating  $\text{Cu}_2\text{S}$  above its inversion point ( $91^\circ\text{C}$ .) or at ordinary temperatures from  $\text{Cu}_2\text{S}$  which contains more than 8% excess S in solid solution. The excess S prevents the inversion to the low temperature form. The somewhat meager X-ray data are in excellent agreement with the  $\text{CaF}_2$  type of structure.

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The last paper was finished at 4:45 P.M., after which it was moved that the thanks of the Society be extended to the local committee, and to the authorities of Case School of Applied Science and Western Reserve University for their kindness and hospitality. This was seconded and unanimously adopted; after which the Society adjourned. At this meeting three memorial biographies and thirty-four scientific papers were presented. This was the longest program ever given before the Society. Seventy-seven fellows, members and guests attended the meeting which was the largest in the history of the Society.

The following registered at the meeting: E. O. Adams, W. M. Agar, V. T. Allen, H. L. Alling, H. M. Bannerman, Miss Florence Bascom, A. M. Bateman, L. S. Brown, J. D. Burfoot, Jr., Lazard Cahn, Miss Ferga Carmichael, R. J. Colony, C. W. Cook, A. R. Crook, E. E. Fairbanks, C. R. Fettke, D. J. Fisher, W. F. Foshag, A. S. Furcron, E. K. Gedney, V. A. Gianella, Russell Gibson, J. E. Gill, J. L. Gillson, James Gilluly, W. A. P. Graham, J. R. Gruner, E. P. Henderson, D. F. Hewett, T. M. Hills, A. P. Honess, W. F. Hunt, P. F. Kerr, D. E. Kerr-Lawson, E. H. Kraus, K. K. Landes, A. C. Lane, E. S. Larsen, J. V. Lewis, J. T. Lonsdale, T. S. Lovering, E. B. Mathews, W. J. McCaughey, B. L. Miller, C. E. Miller, W. J. Miller, E. S. Moore, Charles Palache, W. J. Paquette, A. L. Parsons, A. B. Peck, A. H. Phillips, L. S. Ramsdell, C. H. Richardson, Stephen Richarz, H. Ries, A. F. Rogers, C. S. Ross, Edward Sampson, J. F. Schairer, W. T. Schaller, M. W. Senstius, M. N. Short, C. B. Slawson, R. E. Sommers, M. H. Stow, W. A. Tarr, Ellis Thomson, D. W. Trainer, Jr., James Trythall, F. R. Van Horn, A. J. Walcott, T. L. Walker, Paul Weaver, L. G. Westgate, A. N. Winchell, and A. O. Woodford.

#### LIST OF FORMER OFFICERS AND MEETINGS, WITH DATES

By recommendation of the Council, a complete list of past officers is printed in the proceedings of the annual meeting of the Society.

PRESIDENTS		VICE-PRESIDENTS.	
1920	Edward H. Kraus	1920	Thomas L. Walker
1921	Charles Palache	1921	Waldemar T. Schaller
1922	Thomas L. Walker	1922	Frederick A. Canfield
1923	Edgar T. Wherry	1923	George F. Kunz
1924	Henry S. Washington	1924	Washington A. Roebling
1925	Arthur S. Eakle	1925	Herbert P. Whitlock
1926	Waldemar T. Schaller	1926	George Vaux, Jr.
1927	Austin F. Rogers	1927	George L. English
SECRETARIES.		TREASURERS.	
1920-1922	Herbert P. Whitlock	1920-1923	Albert B. Peck
1923	Frank R. Van Horn	1924	Alexander H. Phillips

#### EDITORS

1920-1921	Edgar T. Wherry
1922	Walter F. Hunt.

#### COUNCILLORS

- 1920 Arthur S. Eakle, Frank R. Van Horn, Fred E. Wright, Alexander H. Phillips.  
 1921 Frank R. Van Horn, Fred E. Wright, Alexander H. Phillips, Austin F. Rogers.  
 1922 Fred E. Wright, Alexander H. Phillips, Austin F. Rogers, Thomas L. Watson.  
 1923 Alexander H. Phillips, Austin F. Rogers, Thomas L. Watson, Esper S. Larsen.  
 1924 Austin F. Rogers, Thomas L. Watson, Esper S. Larsen, Arthur L. Parsons.  
 1925 Thomas L. Watson, Esper S. Larsen, Arthur L. Parsons, William F. Foshag.  
 1926 Esper S. Larsen, Arthur L. Parsons, William F. Foshag, William A. Tarr.  
 1927 Arthur L. Parsons, William F. Foshag, William A. Tarr, Alexander N. Winchell.



## ANNUAL MEETING PLACES

1920	Chicago, Illinois
1921	Amherst, Massachusetts
1922	Ann Arbor, Michigan
1923	Washington, D.C.
1924	Ithaca, New York
1925	New Haven, Connecticut
1926	Madison, Wisconsin
1927	Cleveland, Ohio

## NOTES AND NEWS

THE CONVENIENCE OF A ROTATING TABLE IN THE USE  
OF A TWO-CIRCLE GONIOMETER

SAMUEL G. GORDON, *Academy of Natural Sciences of Philadelphia.*

With the development of the two-circle goniometer by Goldschmidt, mineralogists were given an instrument which obviated the necessity of constantly resetting a crystal. The position of the vertical circle, however, is such as to cause considerable inconvenience in reading. It is necessary to get up and walk to the side of the instrument in order to read the vernier.

The writer is aware of two attempts to overcome this handicap, on one instrument the circle was graduated on the edge; on another, a device for reflecting the vernier, by a system of mirrors, into the same telescope used for reading the horizontal circle, was employed.

The writer has found that a rotating table, of the type that microscopists used for shifting a microscope from one person to another, was most convenient, (Fig. 1).



FIG. 1. Goniometer mounted on rotating table.

This table is 30 inches in diameter, and 29 inches high, and carries the entire instrument and lamp. The axle is 1.5 inches in diameter and 3.5 inches long, and is rigidly

fastened to a steel plate 0.5 inch thick, and 8 inches in diameter. This plate rotates upon a plate of similar size (fastened on a pedestal), in which is a hole in which the axle rotates.

After reading the horizontal circle, a short turn of the table is sufficient to bring the vernier of the vertical circle beneath the eye.

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A series of thirty lectures on X-rays and crystal structure was given by Professor W. L. Bragg at the Massachusetts Institute of Technology during February. An advanced course was also given covering the following subjects: The symmetry of space groups; The dynamics of the crystal lattice; The quantitative treatment of X-ray diffraction; The analysis of complex crystals; and Molecular and atomic structure.

Dr. L. J. Spencer has been appointed keeper of mineralogy in the British Museum of Natural History, succeeding Dr. G. T. Prior who retired on December 16.

The late Professor A. Liversidge has bequeathed to the department of minerals of the British Natural History Museum his mineral collection comprising 2000 specimens, mainly from Australia. The bequest includes about 40 specimens of meteorites; about 40 sections of gold nuggets showing internal structure and about 40 gem stones.

An impromptu dinner party was given by Professor Frank R. Van Horn at the Case Athletic Club on the evening of December 29 in honor of Dr. T. L. Walker's sixtieth birthday. Covers were laid for fourteen guests including the present officers of The Mineralogical Society and as many of the past-presidents as were in attendance at the eighth annual meeting of the Society.

At the last annual meeting the Council of The Mineralogical Society authorized the granting of 50 reprints (without covers) to contributors of *leading articles* that are published in The American Mineralogist. The new rule goes into effect with this issue. As this arrangement will increase the printing costs to the Society it is hoped that contributors will cooperate in an attempt to keep the costs from mounting too high by reducing as far as possible the number of cuts that are sent in accompanying the articles.

## PROCEEDINGS OF SOCIETIES

### PHILADELPHIA MINERALOGICAL SOCIETY

*Academy of Natural Sciences of Philadelphia, January 5, 1928.*

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with an attendance of thirty-three members and twelve visitors. The president, Mr. Clay, presided.

Mr. Arnold Morris was elected a junior member. Mr. J. C. Boyle was elected vice-president and Mr. H. W. Arndt a councillor.

A resolution was passed to extend the felicitations of the Society to Dr. Victor Goldschmidt on the occasion of his 75th birthday anniversary.

The evening was devoted to short reports by various members of their activities in mineralogy during the past year. Among those who participated in this program were Messrs. Warford, Frankenfield, Dipple, Gage, Cajori, Cienkowski, Oldach and Hoadley. Visits to numerous localities and the minerals obtainable at these localities were described in detail.

F. A. CAJORI, *Secretary*.

## NEW YORK MINERALOGICAL CLUB

*Regular Monthly Meeting of October 19, 1927*

The Secretary announced the death on May 21st last of Mr. Mengo L. Morganthau, and offered the following minute:—"By the death upon May 21, 1927 of Mr. Mengo L. Morganthau, a valued member of this Club, and an enthusiastic collector of beautiful and striking mineral specimens, our organization has suffered a severe loss. Mr. Morganthau labored for years in bringing together beautiful examples of minerals, and in spreading abroad the appreciation of these to a very large portion of the community in which he lived. We feel that in thus placing upon our records our deep regret for his death, we are expressing the sentiment of very many of our fellow citizens." This minute was unanimously adopted, and the Secretary was directed to forward a copy of it to Mrs. Morganthau.

It was moved by the Secretary that the Club arrange for an excursion on Election Day. After some discussion in which several objectives were canvassed, it was moved by Mr. Grenzig that the Club visit the Paterson quarries. The motion was carried. It was moved and carried that Mr. Morton act as guide upon this occasion. Mr. Morton then submitted a program for the day which was subsequently embodied in a notice sent out through the N. Y. Academy Bulletin.

The results of the collecting trips during the summer were then discussed by members of the Club. Mr. Manchester showed a series of specimens from Bedford, including a large crystal of ilmenite, hyalite, columbite, terminated black tourmaline, microcline crystals, golden beryl, pyrolusite, dendrites on feldspar, reticulated rutile, scepter quartz, citrine in cut stones and garnet. Mr. Walther submitted a group of Franklin minerals including mcgovernite, hodgkinsonite, lead, allanite, hedyphane, friedelite, pyrochroite, bustamite, leucophoenicite and clinohedrite. Mr. Maynard displayed specimens of thomsonite, datolite, pectolite, and prehnite on datolite from Paterson. Mr. Cooper showed a specimen of ardenneite from Belgium, acquired during his visit to Europe. Mr. Broadwell showed among a large series of Franklin minerals, glaucochroite, mcgovernite, cahnite, hancockite and chlorophoenicite. Mr. F. I. Allen described some twinned labradorite crystals from an Adirondack locality. Mr. Grenzig exhibited terminated pectolite crystals from Paterson. Miss Schroeder spoke on some phases of mining engineering in the tropics, particularly in Panama. Dr. Kerr showed diatomaceous shale from the coast of California, near Santa Barbara, together with specimens of burned shale. The meeting adjourned at 9:15 P.M.

HERBERT P. WHITLOCK, *Secretary*.

*Regular Monthly Meeting of November 16, 1927*

The President announced the death of Mr. George Vaux, Jr., President of the Philadelphia Mineralogical Society, and of Mr. Henry Fair of Spokane, Washington. The Secretary read the following minute which was unanimously adopted:



"The members of the New York Mineralogical Club have learned with deep regret of the death of Mr. George Vaux, Jr., President of the Philadelphia Mineralogical Society.

Mr. Vaux during his lifetime ably carried on the tradition of his uncle and was an enthusiastic, well informed and conscientious collector of minerals, representing a generation of famous private mineral collectors of which he was one of the last surviving. His energy and interest in the field is commemorated in the names of the two mineral species Vauxite and Paravauxite.

To our sister Society and to the bereaved family of Mr. Vaux, the New York Mineralogical Club extends sincere sympathy, and has ordered a copy of these Resolutions to be inserted in the records."

Mr. Morton, reporting on the Election Day Field Excursion to Paterson, N.J., stated that the excursion was successful and that the following minerals were collected on that occasion: From West Paterson,—quartz, calcite, prehnite, datolite, analcite, pectolite, stilbite, natrolite, laumontite, diabantite, chlorite, (other than diabantite), chalcopyrite. From Prospect Park:—quartz, calcite, prehnite, datolite, barite, hematite, chalcopyrite, gypsum, chrysocolla, covellite. He stated that there were in all seventeen species collected from the two localities, though not all by any one member of the party.

The President introduced the speaker for the evening, Dr. Oliver Bowles, of the Bureau of Mines Experiment Station at New Brunswick, N.J., who read a paper on "*Mica, Its properties and Uses.*" Dr. Bowles pointed out the significance of physical properties in determining the uses of the important group of non-metallic minerals with which his Experiment Station dealt. He enumerated these physical properties as possessed by the minerals of the mica group, and pointed out that muscovite and phlogopite were the commercially important micas. Discussing the relation of mica to the rocks he pointed out that the commercial micas occur in some form of pegmatite. The speaker then discussed the many imperfections of the commercial micas, and stated that only 5% of the mica mined was suitable for "sheet mica." He spoke at length of the commercial uses of both "sheet mica" and "scrap mica," giving some production figures. He mentioned "zonolite" and the variety of jefferisite which has lately come into use as a heat insulator, and pointed out how its remarkable change of volume under heat fitted it for this purpose.

Mr. Grenzig in the discussion spoke of some of the electrical uses of mica from the point of view of a practical electrician. A rising vote of thanks was extended to Dr. Bowles and to Mr. Grenzig.

HERBERT P. WHITLOCK, *Secretary.*

*Regular Monthly Meeting of December 21, 1927*

A regular monthly meeting of the New York Mineralogical Club was held in the East Assembly Room of the American Museum of Natural History on the evening of December 21, at 8.15 p.m. The President, Dr. Paul F. Kerr, presided, and there was an attendance of 24 members.

The President introduced the speaker of the evening, Dr. George I. Finlay of New York University who addressed the Club on "*The Minerals of Newry and other Western Maine Localities.*" Dr. Finlay called attention to some of the localities which have long been famous for Maine minerals. He spoke of the peculiar character of the pegmatites as showing evidence of the presence of steam and other gases and



cited this as being responsible for the presence of pockets in the pegmatite and for the presence in these pockets of such minerals as tourmaline, beryl, etc. He spoke of visiting Newry and mentioned the tourmaline material from this locality as not of first gem quality. The quartz of Newry he found rich in spodumene, lepidolite and purpurite. He also referred to indigo blue tourmaline, caesium beryl and supposedly scheelite. He read a long list of the occurring minerals and discussed in detail the chemical composition of a characteristic group of these including autunite, bertrandite, cookeite, eosphorite, herderite, pollucite, triphylite, triplite, reddingite, fairfieldite, dickinsonite, fillowite and triploite. The speaker made free use of a fine suite of specimens to illustrate his address.

Dr. Finlay's paper was discussed at some length by Dr. Kunz and Messrs. Blank and Hoadley. A vote of thanks was tendered to the speaker for his highly valuable address. The meeting was adjourned at 9:30 P.M.

HERBERT P. WHITLOCK, *Secretary*

## REVIEWS

PETROGRAPHISCHE UNTERSUCHUNG ÜBER DIE EIGNUNG VON GRANITEN ALS STRASSENBAUMATERIAL. (Petrographic investigation on the suitability of granite as paving material). ZELTER, W. 69 pages with tables and illustrations. Halle a/S., W. Knapp, 1927.

In Germany where stone is still extensively used for street-paving, granites have been found the most desirable for the purpose. But all granites are not equally suitable and this pamphlet discusses the various physical criteria with special reference to paving.

The first part treats of methods for determining specific gravity, crushing strength, wear-resistance, etc. Emphasis is placed on the importance of petrographic methods as applied to the quantitative determination of each mineral constituent, its form, and size.

The second part contains a discussion of the results obtained in the investigation of 42 samples of granites. Numerous measurements of the principal mineral constituents which were made by the author according to the Rosiwal method, yielded an average quartz content of 31%. This figure is only 0.69% less than the average of 31.69% which Tschirwinski, about 17 years ago, had computed for granites on the basis of chemical analyses. (*N. Jahrb. Min.*, 1913, 2, p. 241).

It may be suggested that the author would have saved himself a great deal of time and labor in his grain-measurements had he availed himself of the recording apparatus described by Hunt (*Am. Mineral.*, 9, p. 190) or Wentworth (*Jour. Geology*, 31, p. 228).

Another point worthy of note is his attempt to compute the actual size of the mineral particles from their linear measurements. Rosiwal (1898) had adopted the factor 1.620 by which the average diameter of the measured grains must be multiplied. Recent mathematical computations by Grengg and Mader (1925) have yielded a factor of 1.2337. As this discrepancy of 31.31% is too great for scientific purposes, the author has tried to determine the correct value experimentally. His procedure was briefly as follows: Lead shot of known diameter was imbedded in Wood's metal; constant shaking and rapid cooling prevented the shot from sinking to the bottom. Plates 1/2 cm. in thickness were then cut, ground and polished. The

sections of lead shot stand out clearly as dark spots in a lighter medium and can be easily measured. In this way a factor of 1.2721 was found, which is much closer to Grengg and Mader's value than to the original Rosiwal factor.

M. W. SENSTIUS

DIE ROLLE KOLLOIDER VORGÄNGE BEI DER ERZ- UND MINERAL-BILDUNG, INSBESONDERE AUF DEN LAGERSTÄTTEN DER HYDROSILIKATISCHEN NICKELERZE. (The rôle of colloidal processes in the formation of ores and minerals, with special reference to the hydro-silicate nickel-ores). SCHORNSTEIN, W. 87+IV pages with 25 tables. Halle a/S., W. Knapp, 1927.

This is a report on an extensive series of experiments, which were carried out during the years 1911—1914 to explain the origin of nickel-ore deposits derived from serpentinized basic igneous rocks, such as occur in New Caledonia, near Riddle, (Oregon), and Webster (N. Carolina). It was assumed that these hydro-silicate nickel-ores were due to the decomposition of Ni-bearing serpentines under the influence of meteoric or thermal waters containing  $\text{CO}_2$ . The mechanism of their possible deposition and concentration was studied on a large range of artificially prepared gels, such as might be present in the formation of hydrous Ni-Mg-silicates and Co-Mn gel minerals. These gel-minerals which do not represent definite chemical compounds but rather a more or less intimate mixture of different substances, may be formed; (a) by simultaneous precipitation from mixed or colloid-complex sols; (b) by precipitation of one sol upon the surface or within another gel; (c) by absorption of a molecularly dissolved substance by a gel of another substance; (d) by infiltration of the solution of one substance into the gel of another; (e) by chemical reactions between true solutions and colloiddally dispersed substances.

The experimental results and their discussion, while too extensive for an adequate review in these pages, are very suggestive and throw considerable light on many related problems of secondary enrichment by percolating waters.

M. W. S.

APPENDIX TO THE CATALOGUE OF METEORITES WITH SPECIAL REFERENCE TO THOSE REPRESENTED IN THE COLLECTION OF THE BRITISH MUSEUM (NATURAL HISTORY). G. T. PRIOR. Printed by order of the Trustees of the British Museum and sold at The British Museum, Cromwell Road, S. W. 7, London, 1927. Price two shillings.

This appendix of forty-eight pages contains an alphabetically arranged list of the names and descriptions of meteorites which have been found since 1922, together with the names of a few older falls which were omitted in the original Catalogue. The Catalogue and the Appendix now contain all the described meteorites up to the end of July 1927.

W. F. H.